WADC TECHNICAL REPORT 58-397
ASTIA DOCUMENT No. AD 216307

# DEVELOPMENT OF AN EMERGENCY PRESSURIZATION SYSTEM FOR AN ESCAPE CAPSULE

*A. E. Miller*
*E. H. Replogle*

*Scott Aviation Corporation*



*MAY 1959*

Contract No. AF 33(616)-5005

AERO MEDICAL LABORATORY
WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

## NOTICES

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## FOREWORD

This report by A. E. Miller and E. H. Replogle, Scott Aviation Corporation, Lancaster, New York, covers the development of an "Emergency Pressurization System for an Escape Capsule" developed under Contract AF 33(616)-5005, Project 6352, with the Aero Medical Laboratory, Wright Air Development Center. Mr. Herman H. Dees was the contract monitor.

The contract monitor wishes to express his appreciation to Mr. E. A. Horns, Mr. Kent W. Gillespie, Mr. J. D. Bowen, and other individuals of the Aero Medical Laboratory for their valuable assistance.

## ABSTRACT

An Emergency Pressurization System for an Escape Capsule was developed. It included its own "bottled" high pressure air supply and a sequential system of controls whereby, after being armed either manually or by separation from the aircraft, the system automatically (as a result of the sensing of the drop of cockpit pressure) releases its air at the rate required for fast repressurization. It then cuts short the fast repressurization as soon as the capsule pressure has again returned to a safe level, and directs the air through an absolute pressure regulator which maintains this level, compensating for capsule leakage.

It was found that the second aneroid triggering device could be set off prematurely by shock waves formed by the too sudden release of unrestricted pressure when attempts were made to repressurize in times considerably shorter than five seconds. The pressure waves were recorded and means devised to avoid them.

The reasons for choice of the types of mechanical elements provided and the effects of acceleration and environment on their satisfactory operation are discussed. A brief review of the test results is included, and the report is concluded with recommendations to writers of future specifications for equipment of this nature.

## PUBLICATION REVIEW

The publication of this report does not constitute approval by the Air Force of the findings or conclusions contained herein. It is published only for the exchange of information and stimulation of ideas.

FOR THE COMMANDER:

Fred W. Berner

FRED W. BERNER
Technical Director
Aero Medical Laboratory

TABLE OF CONTENTS

## LIST OF ILLUSTRATIONS

# SECTION I

# INTRODUCTION

The purpose of this investigation was to perform a design study of a self contained emergency pressurization system for an escape capsule. Three prototypes were developed, built and tested. This report lists information on all phases of the developement.

Most of the design criteria and preliminary designs were presented in Scott Engineering Report No. 585, "Report on the Design Study". Scott Engineering Report No. 585 also dwells at some length on the reasons for selection of the type of sequencing and system used. The information contained in Scott Engineering Report No. 585 has proven valid and was used in the developement of the prototype units. Scott Engineering Report No. 585 has been included in this report as Appendix I.

This report dwells primarily on the more controversial aspects of the design, the mistaken assumptions, the changes found necessary, the application of the previously developed "Aneroid Motors" to this purpose, the test results, and the knowledge gained which may be useful to future specification writers and designers of this type of equipment.

In addition to the results of actual experiences with the units, some analytical data on the design which was necessarily calculated during the design phases and which may be of general interest have been included.

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Manuscript submitted by the authors for publication as a WADC Technical Report in September 1958.

# SECTION II

## THE SYSTEM AND ITS OPERATION

The system developed provides a means for automatic or manual arming through a pull cable, after which it is automatically actuated when the cabin pressure is reduced to the equivalent of 11,000 ft. altitude. The immediate result of this actuation is to provide a high flow rate of air in sufficient volume to bring the capsule pressure back to the equivalent of 9,000 ft. (from 75,000 ft.) in 5 seconds. When the pressure has been restored, a second actuation occurs at 9,000 ft. which directs the remaining air supply through an aneroid-controlled absolute pressure regulator in order to maintain an equivalent altitude of between 8,000 and 12,000 ft. against a leakage rate as high as 25 liters per minute for a period of 10 minutes.

The basic system required to accomplish these functions entails only three major components; an air supply reservoir, an automatic repressurization valve, and an absolute pressure regulator. Supplementary to these primary elements, an L-2 gage, an MS 28889-1 charging fitting, and a safety outlet for overpressure blow-off are supplied. As supplied to WADC, these elements are all mounted directly on the air cylinder as shown in the accompanying photograph, Fig. 1.

The following section will take up these elements separately and explain their design and function:

### 1. Elements of the System

The repressurization valve portion of this unit is of the disc type seating on an annular-lipped orifice. It is guided by a plunger and normally held closed by a toggle and crank linkage which is locked in the dead center position. When the toggle is moved away from dead center, the valve if permitted to travel far enough will backseat against a nylon seat. The disc valve is backed up by a tulip-shaped head which has petal-like guides on its periphery so as to provide guidance but still permit air to flow freely by the head and cut diffuser holes next to the stem guide. Fig. 2 is a schematic view of this arrangement and illustrates the type of structure of the valve (simplified) as well as its operation.

From Fig. 2 we see that in position 1, with the toggle on dead center, the valve is held firmly against the seat, and the cylinder pressure is sealed off. The "first sear" is used to hold this linkage at dead center and maintain the valve in the closed position against a constant spring load applied at the outer or right end of the crank.

The "first aneroid" assembly is mounted in position to release the "first sear" when the aneroid expands due to a drop in pressure, and a safety cam or lever is used to prevent any movement of the aneroid until the unit is armed by a pull cable which rotates the safety cam out of the way. The "first aneroid" assembly is an "aneroid motor", as explained in the following text, and will not apply any opening force to the cam until it reaches its "trigger" altitude of

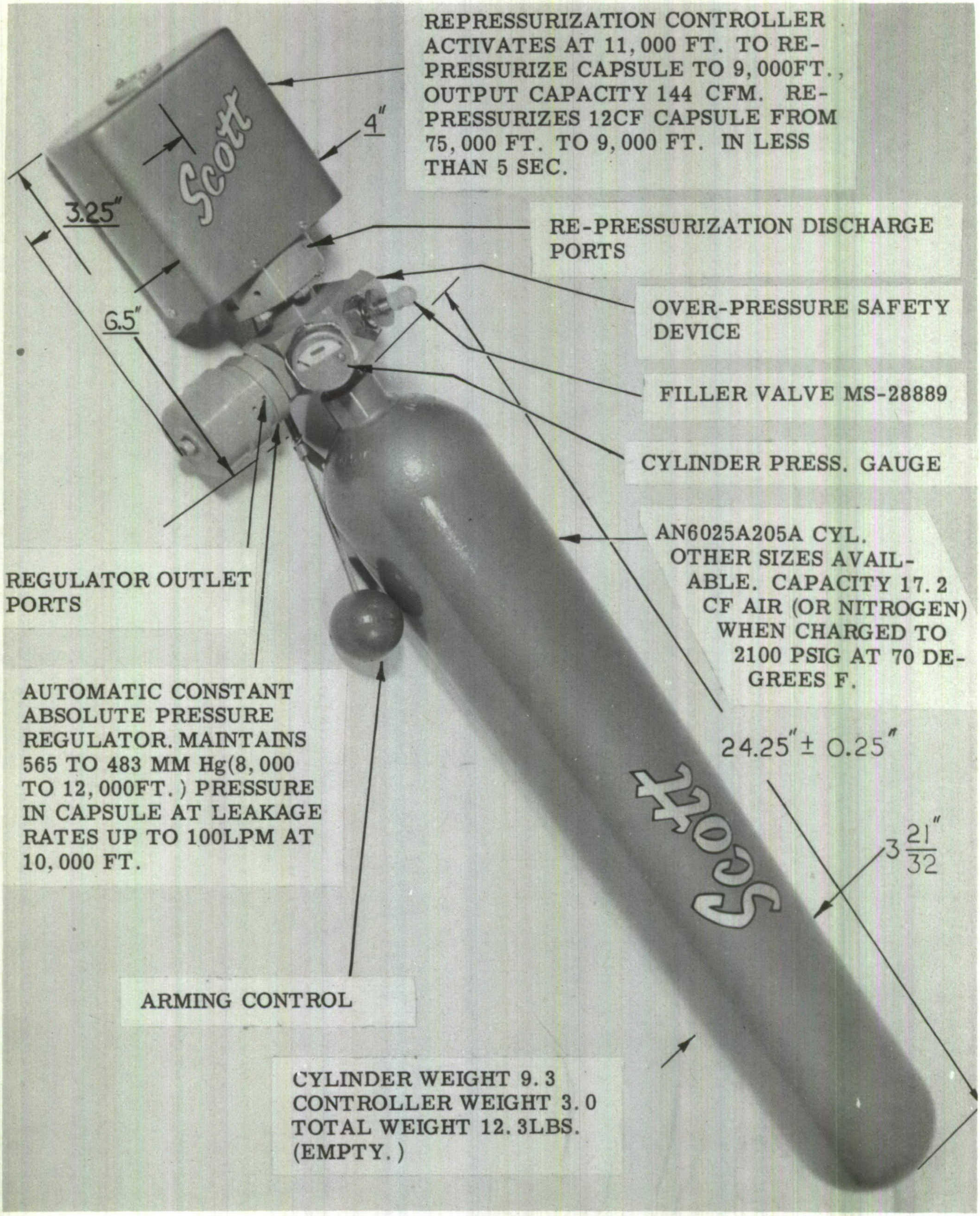



Figure 1. 11700 REPRESSURIZATION SYSTEM

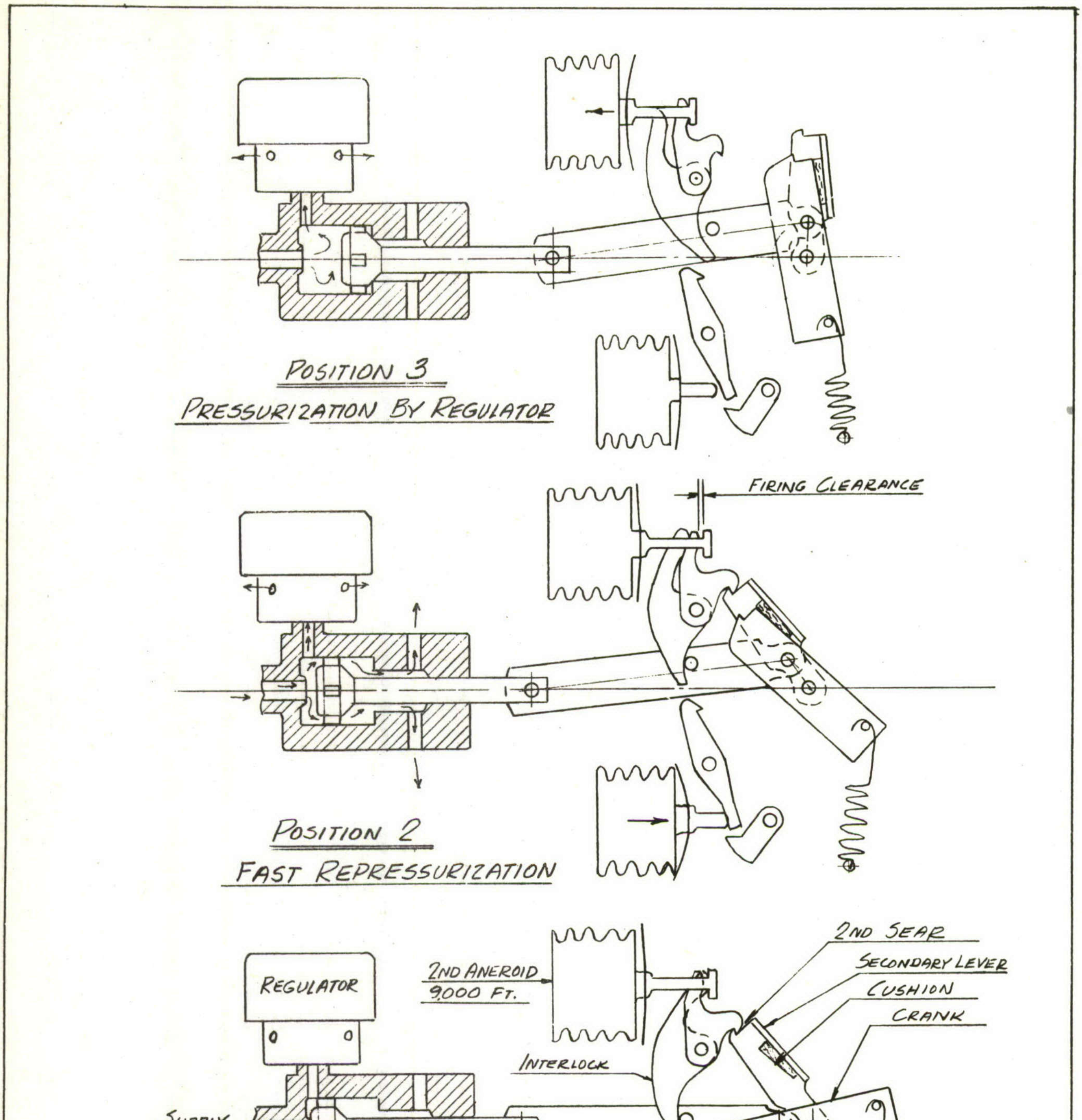



Figure 2. OPERATING SCHEMATIC

11,000 ft. In fact it must travel 0.025 inches before it contacts the sear lever.

It may also be seen from Fig. 2 that there is a "second sear", (in position to be released by a "second aneroid" motor) which sear retains a "secondary lever" which is also spring loaded against it (spring not shown). This "secondary lever" when retained by its sear is in position to act as a partial travel stop for the toggle linkage and contains an energy-absorbing cushion for contact with the fast-moving toggle linkage.

This basic linkage is completed by an interlock lever, one end of which bears against a roller on the toggle link, the other end maintaining tension on the stem of the "second aneroid" so that the aneroid cannot retract or actuate regardless of altitude. The design of the interlock is such that, as the toggle link moves away from dead center, the interlock will then relax its force on and move away from the aneroid stem, freeing it so that when it actuates and takes up the 0.025 inch firing clearance, it will release the sear on the "secondary lever". The interlock, therefore, safeties the "second aneroid" until the first has fired and released the toggle from dead center.

On examination of the above described linkage, one will find that the two sear levers are both of two-piece construction; however, this is for cocking purposes only and does not affect the operation which we will now describe.

Referring again to Fig. 2, let us follow a typical cycle of operation of this aneroid-controlled valve. In normal flight, the unit is in position 1 with the safety lever in the "safe" position as shown in phantom. In an emergency such as an engine failure where gradual loss of cabin pressure may occur, the pilot may manually pull the arming cable. If he ejects, the unit will be armed by the act of separation of the capsule from the aircraft, the arming cable end being attached to the aircraft as a lanyard.

After arming, the safety lever is in the solid line position; the unit is now ready to operate at any time the capsule pressure drops to 11,000 ft. As this occurs, the aneroid motor suddenly expands with a "snap" action, collides with the sear lever, displaces it, allowing the toggle lever to snap open (as in position 2) under the spring load.

As the toggle moves away from a "dead center position", the valve pressure load assists in opening the valve. The toggle links then travel until the crank impacts against the secondary lever where it is stopped and held as in position 2. Under these conditions the valve is opened but not backseated. The released air may now rush past the valve head, through the backseat, and out the diffuser holes into the capsule. This allows for quick repressurization of the capsule; the only rate-of-flow control being that resulting from preselection of the valve orifice size and the resistance of the exhaust system.

It will be noted that at this stage in position 2, the interlock has now released its restriction on the tension aneroid, the bellows remaining extended only because the cabin altitude is now above the 9,000 ft. level of pressure. Therefore, the secondary lever continues to be held by the second sear and the fast escape of air is maintained until the pressure increases sufficiently to collapse the second aneroid, which occurs at 9,000 ft. As this occurs, the bellows collapses or retracts with a "snap" action, the stem (after taking up the firing clearance) pulls the second sear out of engagement permitting the secondary lever and the toggle linkage to con-

tinue its previously interrupted travel until the valve backseats, sealing off the exhaust ports and forcing all the remaining air through the absolute pressure regulator which maintains the reattained capsule pressure against leakage. This situation is shown as position 3 of Fig. 2.

This valve is shown in detail in Figs. 3, 4 and 5. It may be reset by three simple steps. Valve stem load adjustment (in case of leakage) is provided for as shown in Fig. 4.

2. The Aneroid Motors

The aneroid motors furnished to control the above described repressurization valve are of a unique design previously developed by Scott Aviation Corporation for use in automatic barometrically controlled oxygen valves. Each motor consists of a frame containing an aneroid with internal spring and anti-collapsing stop, an end-loaded thin-metal reed, the center of which is attached to the live end of the aneroid, and an adjustable stop which is rigged to provide a resting position for the reed-aneroid combination very close to an imaginary line drawn between the ends of the reed (dead center).

The reed, by virtue of its end load, tends to seek a bowed position on either side of dead center. If, from its natural bowed condition on one side of dead center, it is forced through dead center to a stop which is rigged close to dead center on the other side, the reed will rest against this stop and store most of the energy which was required to initially push it through center or to "cock" it. Since the reed acts like a toggle which is held close to dead center, it takes very little force to push it away from the stop and through center to its original position. As we do this, the reed "snaps" through center releasing all its stored energy which can be utilized as a force capable of actuating a valve sear or other mechanism.

If the balance of forces in the reed is further analyzed, it is apparent that when against the stop and when supported in low friction knife-edge at its ends there is a very high static mechanical advantage and the comparatively light load required to move it off the stop is both analytically predictable and highly repeatable. As the stop is adjusted closer to dead center, the mechanical advantage becomes higher, and the load with which the reed bears against the stop becomes lower. When this load is overcome, the reed will lift from its stop and snap to its "energy released" bowed condition.

It is then seen that it is possible and practical to so end-load the reed that considerable force is required to cock the reed (push it through center), say a peak load of 9 lbs., and yet to release this stored energy a light load, say of only 1 lb., will suffice. The net result is a great amplification of the triggering load.

If an aneroid is used to push this reed off the stop, the resulting combination is a highly accurate altitude control which provides great amplification of the energy normally available from the aneroid. Since the reed is "force-sensitive", requiring a definite load to push it away from the stop, and since the aneroid, when prevented from moving, is capable of supplying a force exactly proportional to an equivalent altitude pressure, we have the exact ingredients required for a pure altitude control which is capable of releasing stored external energy (put into it by cocking) for amplification of aneroid energy.

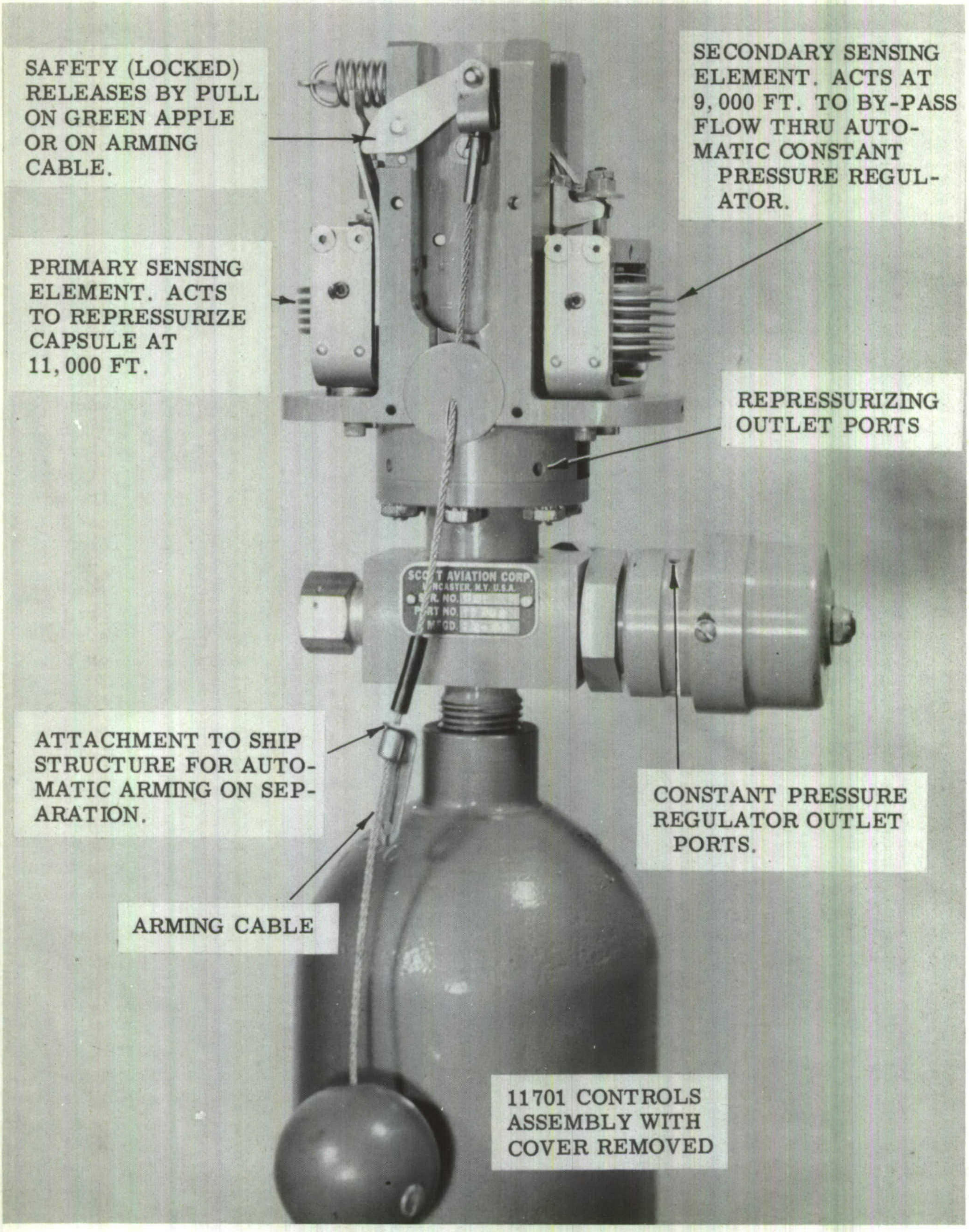



Figure 3. CONTROL ASSEMBLY, COVER REMOVED, CABLE SIDE

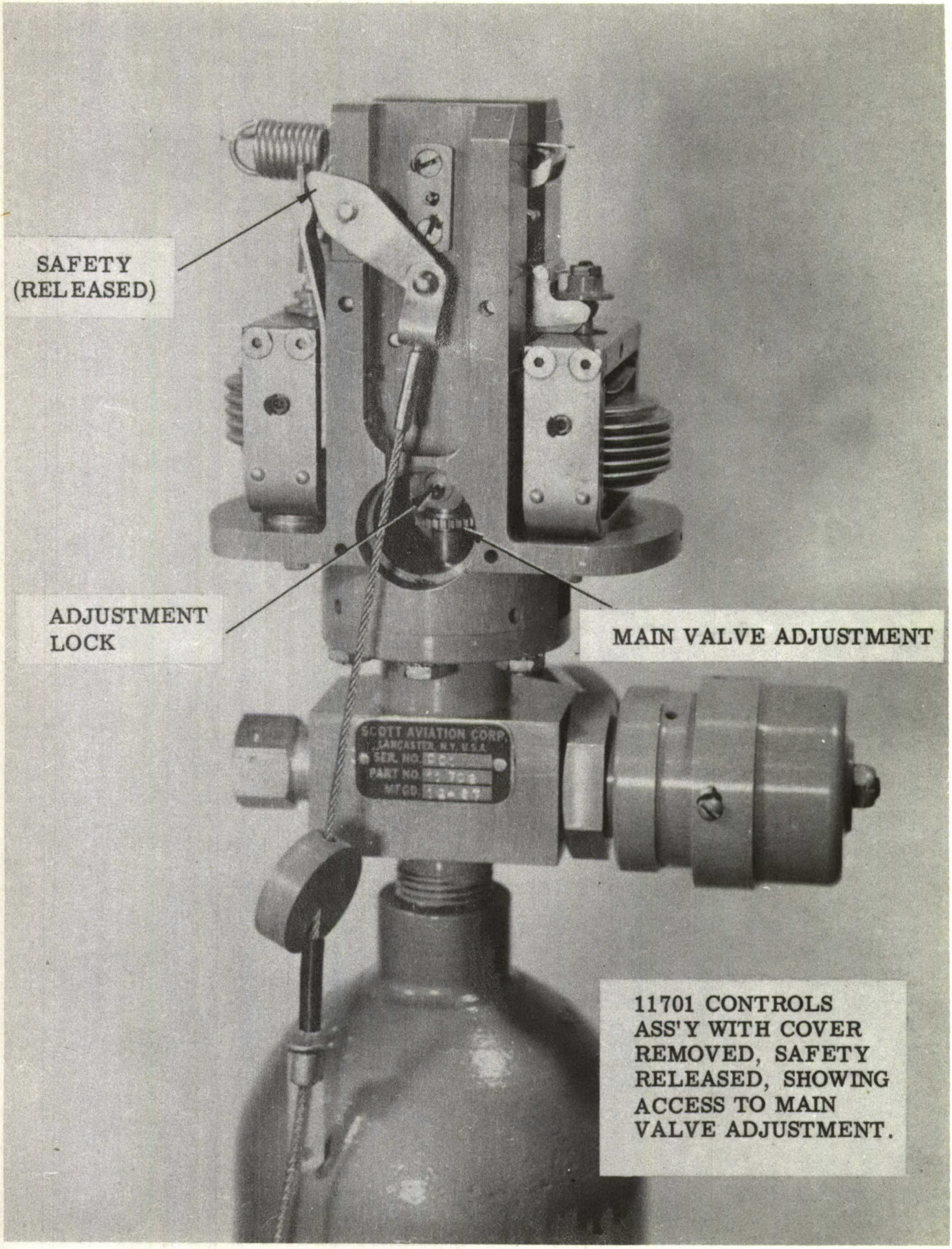



Figure 4. CONTROL ASSEMBLY, COVER REMOVED, SHOWING VALVE ADJUSTMENTS

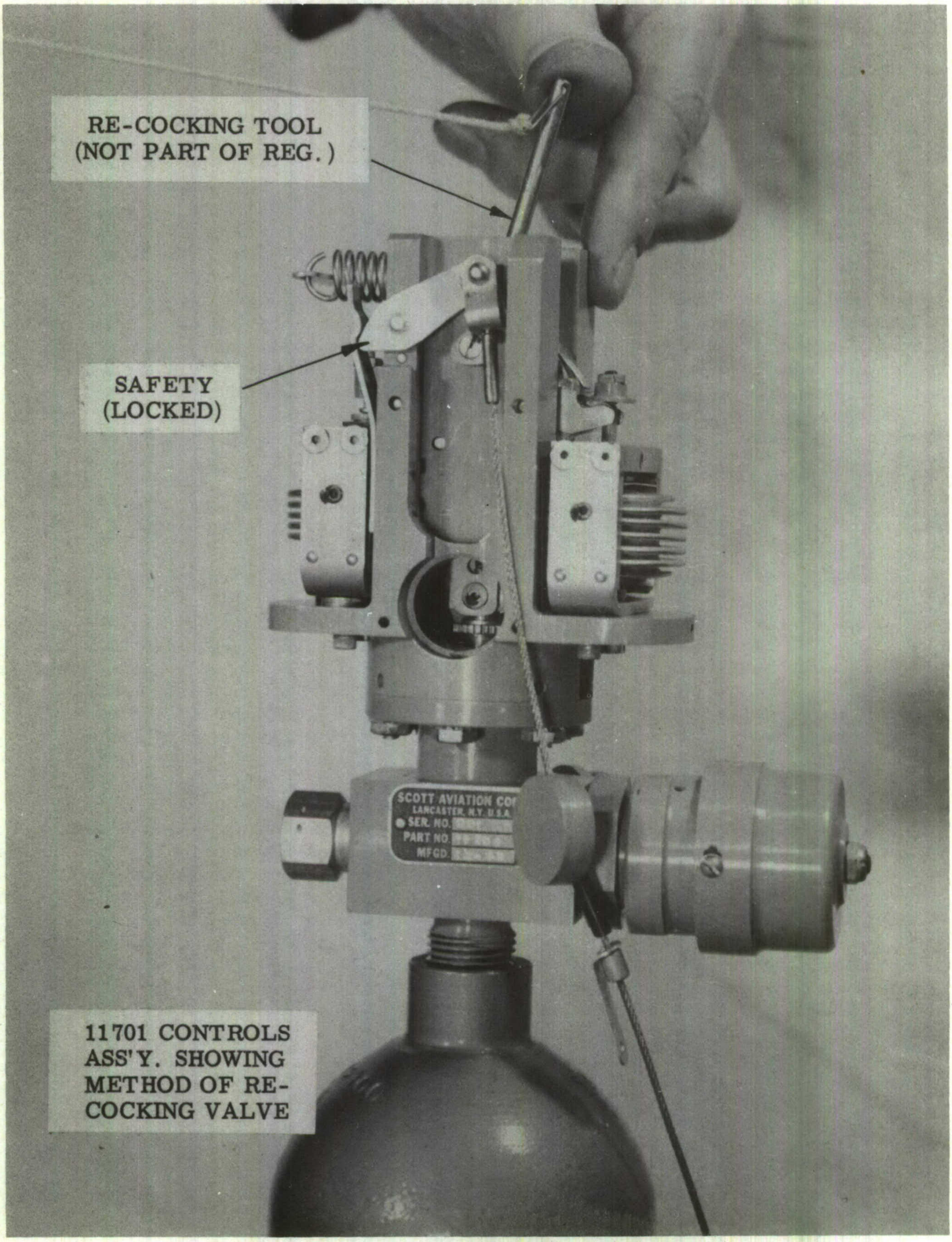



Figure 5. 11701 CONTROLS ASS'Y. SHOWING METHOD OF RECOCKING VALVE

In order to attain this in practice, careful design and balancing of frame spring rate and strength are necessary. The stresses are very high if high output is desired because of the high end-load required at the reed. The reeds used require a peak cocking force of about 9 lbs. and therefore deliver this load when actuated.

Two such aneroid motors have been provided in the system described herein. The first aneroid is of the "compression" type so as to act on expansion (increasing altitude); the second being "in tension" acts on contraction (decreasing altitude). The first aneroid reed requires 1-1/4 lbs. to displace it, the second requires 2 lbs. The difference in load is because of differences in output requirements and because of limitations of the aneroid assemblies. Both reeds deliver maximum output forces of close to 9 lbs. although the average output force is about 5 lbs. for a distance of about .065 in effective stroke to give about .325 inch-pounds of output energy. Added to this is the aneroid energy which, on the second aneroid, averages about 1.2 lbs. through the effective stroke and adds .078 inch-pounds for a total energy output of .403 inch-pounds from the second aneroid. Although the sears require much less energy than this for their release under ordinary conditions, the extra energy is desirable for a safety factor. Also, the impact delivered at the end of the .025 firing clearance is a great help in breaking static friction.

It will be noted that these aneroid motors are actually clear of their sears by .025 inches and apply no force at all until the instant of firing. Therefore the firing altitudes are very accurately repeatable, on the order of plus or minus 100 ft., even under extreme variations of environmental and mechanical conditions.

Setscrews are provided at each end of the reed to adjust end loading, and stop adjustment is provided to adjust firing load. The aneroid shaft is mounted through the frame and adjusted by the moving of two nuts for altitude adjustment. These adjustments are all precise, requiring considerable experience to accomplish properly, and are considered permanent factory adjustments; they are therefore sealed with a locking compound (Glyptol).

Since there is no movement of parts before the triggering point of the aneroid is reached, there is no problem of internal vibratory resonance causing premature operation. The aneroid is affected only by accelerations applied to the base upon which it is mounted. These, of course, may result from steady state or vibratory conditions. Since there are no internal resonant problems, the effects on the aneroid motor firing point may be determined by static analysis of the masses of the movable parts bearing on the reed, and the reed itself. The product of their weight times the acceleration applied produces an actuating force. This firing force in pounds may be reduced to effective altitude error by dividing it by aneroid effective area to get an equivalent pressure and equating this to an equivalent altitude error taken from the 10,000 ft. point.

The effect of 20 G acceleration was calculated as follows:

| | |
|---|---|
| .50 x spring weight | = .00975 |
| .50 x bellows weight | = .01490 |
| Total head weight | = .03190 |
| Total stem tension aneroid hardware | = .00250 |
| .666 reed weight | = .00303 |
| Total Effective Weight | = .06208 |

At 20 G's $W = 20 \times .06208 = 1.24$ lbs.

$$\text{Equivalent pressure} = \frac{1.24}{1.18 \text{ sq. in.}} = 1.05 \text{ psi}$$

Equivalent altitude arror = 2,750 ft.

This applies to the aneroid assembly (Bridgeport Thermostat Co. Inc. No. S102026) which was used in the prototype. It was realized that this aneroid is equipped with an unnecessarily heavy head, but since time did not permit fabrication of special aneroids, this assembly was used and proven to be adequate.

By disassembling the aneroid assembly and reworking the inside of the head, .0132 lbs. could be removed which would reduce the 20 G error to 2,160 ft.

Since within the range of altitudes under discussion altitude-pressure variations are reasonably close to a linear relationship and accelerations effects are exactly so, the acceleration error curve has been plotted as a straight line in Fig. 6. It will be noted that for the standard S102026 bellows an acceleration of 7.3 G's would cause an error of only 1,000 ft., which is considerably less than the variation allowed by the revised specification requirements. Extra work on the bellows head would have allowed 9.4 G's per 1,000 ft. error which did not seem to be enough improvement to warrant the required delay, especially in view of the fact that the performance was already within specification tolerance.

In production, a type of bellows with an integral sheet metal head should be used in lieu of the present type which incorporates a machined brass head. By the use of the integral head (with proper stiffening), the total effective weight can be reduced from the present .06208 lbs. to only .03168 lbs. The 1,000 ft. error would then not result until 14.4 G's were imposed; the effect of acceleration would be only half of the present effect. A plot of this line is also shown on Fig. 6 which represents the acceleration tolerance which the production articles should exhibit. This indicates that within the range of reasonable tolerance the error should be held to less than 2,000 ft.

One might ask, "why not balance the movable aneroid mass in order to eliminate acceleration error altogether?" It must be remembered that if a balance linkage is used, it must move in opposite direction simultaneously with the bellows and represents not only more moving parts, but more friction, greater probability of malfunction, and decreased reliability. Also, unless the balance linkage is carefully designed, it will be responsive to angular acceleration error which may be just as intolerable as the effect of linear acceleration. Since the effects of tolerable accelerations can be held within reasonable limits with the present design, it is felt that it would be a strategic error to include a balancing device in such a control.

3. Absolute Pressure Regulator

The regulator design is not unconventional except that it is extremely compact and quite small for its capacity; also it is a fully aneroid-controlled device.

It is a two-stage regulator of coaxial design as shown in Drawing No. 11703. The first stage valve is of the disc type, seating against an annular-lipped seat. A spool of two different areas is used, the first stage pressure and air

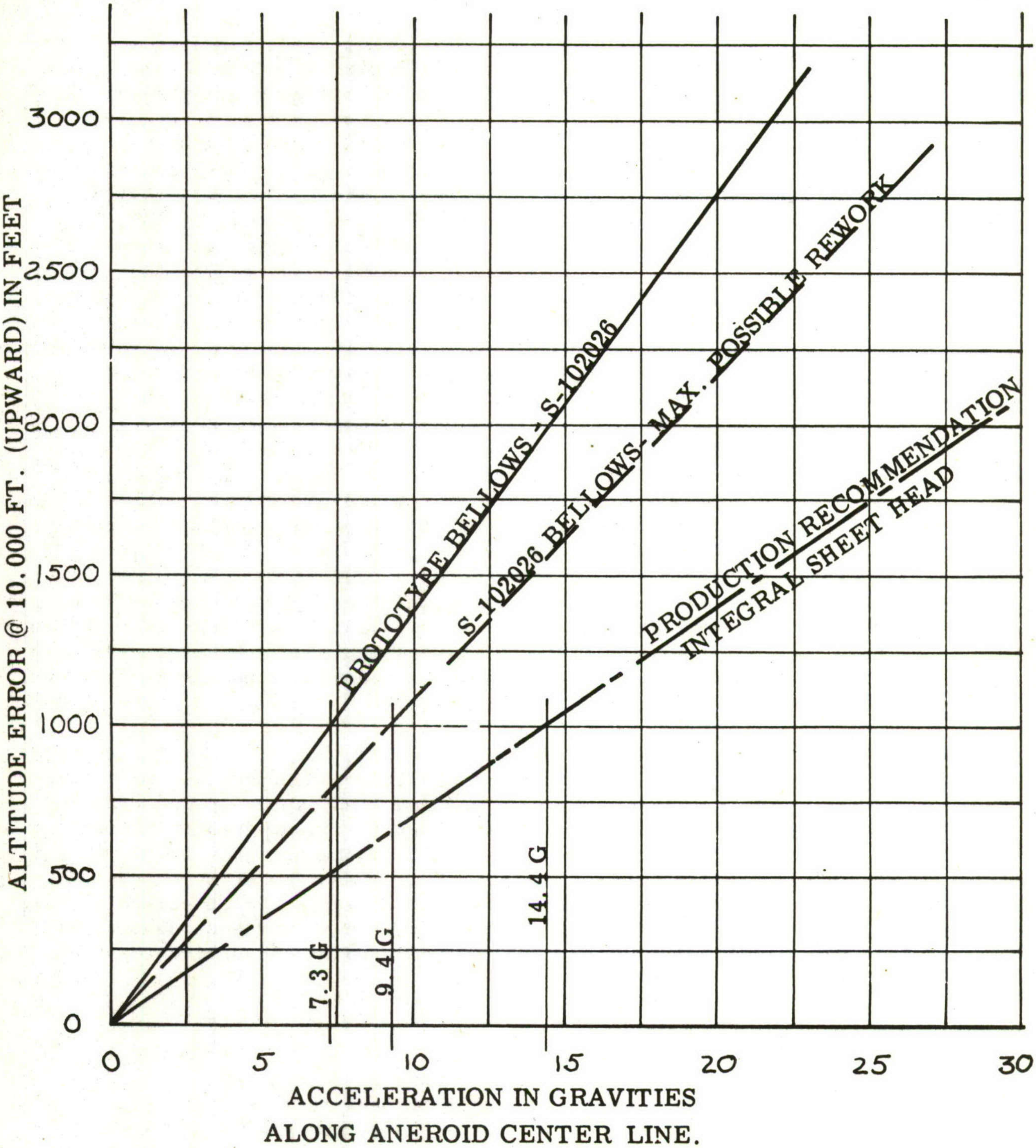



Figure 6. ALTITUDE ERROR VS ACCELERATION

passing through the drilled axis of the spool to reach the second stage valve. Silicone rubber "O" rings are used as sliding seals on the first stage; dry Molykote lubricates the bores of the cylinders in which the seals function. These rings are only pressurized during the operating cycle, and movement of the seals is extremely slight.

The second stage consists of a 90° included-angle conical valve seating in an orifice machined into a nylon seat block. The valve stem contains a snap ring groove under which is compressed a small closing spring. The aneroid is mounted rigidly in the fore end of a cylindrical case, the entire case being rotated for altitude adjustment. The "live" end of the aneroid bears directly on the tip of the second stage valve stem.

This regulator is required to provide 25 liters per minute within a 2,000 ft. error. Actually it has considerable excess capacity, being capable of a true conservative rating closer to 100 liters per minute.

A two-stage regulator has been selected because it is much smaller and lighter than an equivalent single stage would be, because of the much larger aneroid required on the latter.

4. Miscellaneous Equipment

The air reservoir supply is an AN6025A205A cylinder which supplies a surplus of 10% over specification requirements when charged with air to 1800 psi. It is directly interchangeable with the AN6025A205 which is a shorter, larger diameter cylinder of the same capacity.

A standard USAF charging fitting MS 28889 is provided for filling the supply cylinder. A gage was deemed necessary to check for full air supply; therefore a Type L-2 gage, with dial converted for use of air instead of oxygen, is provided in order to conserve space and weight. To provide an overpressure blow-off in order to prevent explosion of a cylinder in the event of exposure to a fire, a Scott "safety outlet assembly" No. 10707-2 is provided with a fitting for attachment of 5/16 inch tubing for an overboard blow-off.

A 1/16 diameter arming cable is provided, terminating in a conventional "Green Apple" and provided with an intermediate connection for an additional lanyard. All of these items are assembled directly on the valve block which in turn is assembled directly to the cylinder. The valve block and the cylinder may be separated by plumbing, if necessary or expedient due to space limitations within the capsule.

## SECTION III

## TEST PROGRAM

A test setup basically similar to that proposed in Fig. 6 was constructed. It consists basically of an 82-gallon tank, which formed the main volume of the system, connected by 1-1/2 inch pipe (2-1/16 inch O.D.) to a bell jar chamber, with a quick operable gas cock type valve interposed in the pipe.

A vacuum pump was connected to the tank through a Fischer & Porter "Flowrator". A mercury manometer was mounted in such a way as to provide an altitude reading of either the tank or of the bell jar pressure, at the choice of the operator. The manometer scale was adjusted to correct for barometric pressure existing at the time of the test.

A recording barograph with a 6-minute drum and scale expanded at low altitudes was used primarily for recording time and for obtaining a generalized record "picture" of the test results. Due to inadequate space for the recorder under the main bell jar, a small separate bell jar base and jar were provided for this purpose, being connected to the main bell jar with a short section of vacuum line. This enabled one to observe the recording as it progressed and still permitted the use of a metal bell jar over the pressurization system where the use of glass was considered hazardous.

A small bypass line connecting the tank directly to the main bell jar was provided so that, with the gas cock closed, the bell jar could be evacuated in a conventional manner for setting aneroids, checking regulator flows, etc., and other detail portions of the cycle.

An "O" ring sealed shaft was also provided through the main bell jar base for operating the manual arming cable.

An extension fitting welded vertically through the bell jar base connected the repressurization control valve inside the bell jar with the air supply cylinder outside. The supply cylinder was screwed onto the lower (outside) end and the repressurization system to the upper end of the extension above the bell jar base. Into this welded-in extension was mounted a charging line so that the units could be charged quickly from a high pressure cascade of compressed air cylinders even when under the bell jar, or when wrapped with insulation and packed with dry ice for cold tests.

With the repressurization unit cocked and charged, the gas cock closed, the main 82-gallon tank evacuated to 75,000 ft., the recorder loaded and running under its bell jar, and the vacuum pump running at a rate such as to pump 25 liters per minute at 10,000 ft., a typical repressurization cycle was simulated as follows:

First, the main gas cock was just slightly cracked open until an 8,000 ft. altitude was reached in the bell jar, thus simulating normal cabin altitude in flight, then the valve was reclosed, and the unit was armed. The gas cock was then opened abruptly and completely, causing an abrupt rise in altitude within the bell

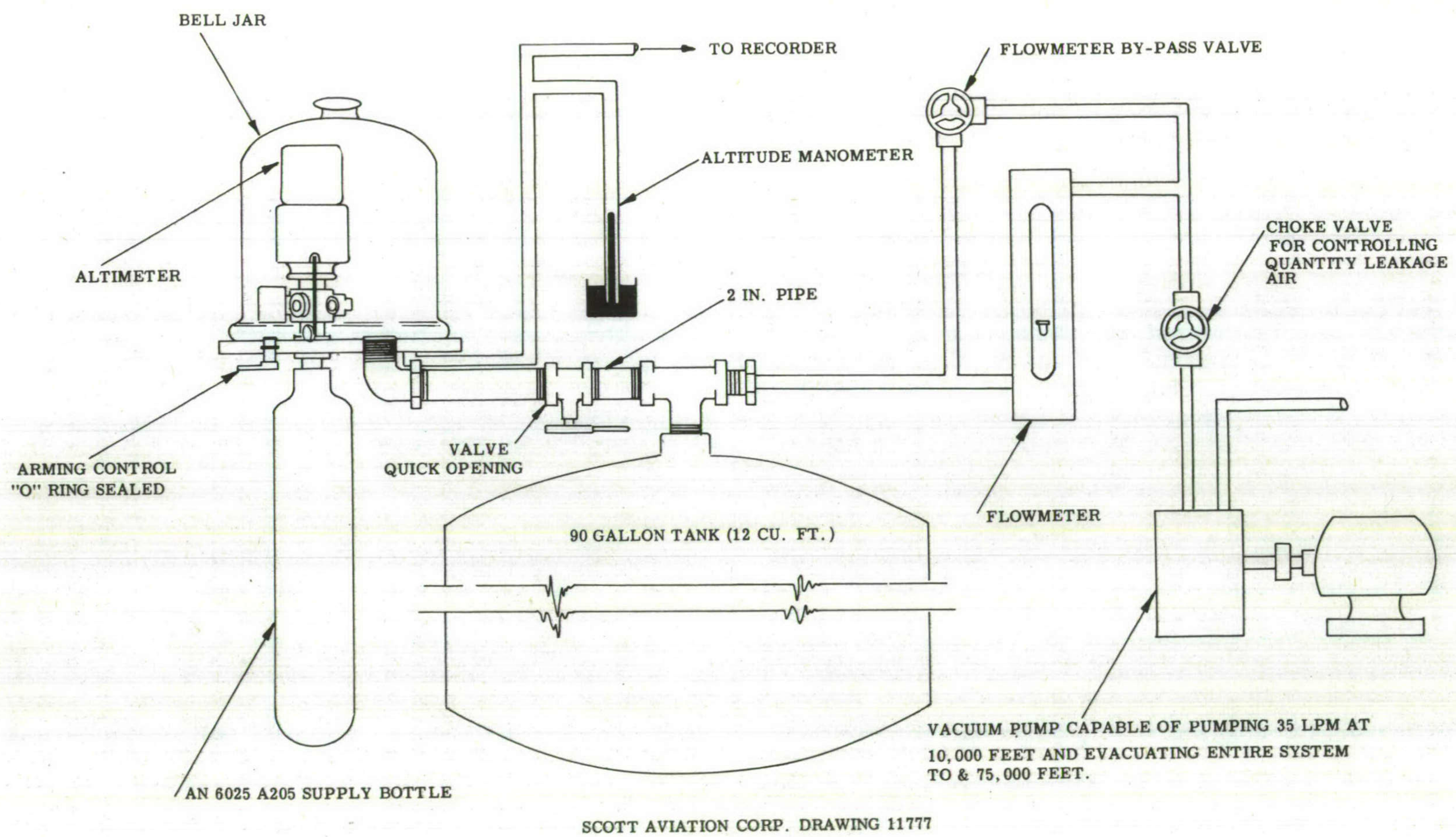



Figure 7. TEST SET UP- PROPOSED CAPSULE PRESSURIZATION.

jar and triggering of the first aneroid at 11,000 ft. The released air flowed to the tank freely through the large diameter pipes. As the pressure rose and equivalent altitude descended, the second aneroid was automatically triggered, cutting off the high volume flow as 9,000 ft. was reached. After this main flow was automatically cut off at 9,000 ft., the vacuum pump working at the prescribed maximum leakage rate of 25 liters per minute quickly raised the altitude to 10,000 ft. where regulation by the absolute pressure regulator began and where this altitude was maintained.

Obviously, in order for a test setup of this type to be successful, the pipes must be large enough to freely pass the required amount of gas; otherwise, due to pressure drop in the line, the pressure in the bell jar will build up sooner than the tank pressure is replenished and cause premature firing of the second aneroid. One must also be careful to abruptly and completely open the gas cock or the same failure will occur. The capacity of the setup can be tested by evacuating the tank to 75,000 ft. and then without a bell jar in place, abruptly open the valve as described above and repressurize the tank to 9,000 ft. by atmospheric air. This should require no longer than 3.5 seconds for the test setup to be adequate for a 5-second repressurization under normal test procedure.

1. First Prototype Tests, Serial No. 001

High pressure flows through orifices and labyrinthic exhaust systems, such as those around the tulip valve head and through the diffuser holes and under high pressure, are difficult to calculate with any degree of accuracy. Therefore, the policy of providing a considerably oversize valve orifice was adopted with the idea that there would then be excess capacity for fast repressurization and that it could be controlled or slowed down by restricting the outlet ports as required by the first test results. Number 1 unit was, therefore, produced with a 3/16 diameter valve orifice.

After carefully setting up the proper triggering altitudes on each aneroid and checking the function of all elements separately and in sequence, but without pressure in the supply tank, the unit appeared to be in perfect working order.

Complete cycle tests were begun at low supply pressures and low tank altitudes. The unit operated perfectly until the supply pressure was raised to 350 psi. At this pressure or above, the second aneroid would fire immediately with the first completely skipping the fast pressurization phase, because the valve was backseating and activating the regulator only at the instant of pressure drop. The recorder, which was in a separate bell jar, furnished no clues as to the trouble.

Finally, a large (10-gallon) container was substituted for the bell jar. This allowed space to mount the barograph directly on top of the unit. On the first such test, the recording showed the trouble. A shock wave was formed immediately with the firing of the first aneroid which caused a momentary pressure rise to a pressure well below the preset firing altitude of the second aneroid, thus causing it to fire prematurely (see Fig. 8a).

It was theorized that if the valve orifice were throttled (in the throat of the valve) permitting an appreciable pressure drop before this air emerged into the outer atmosphere, the severity of the wave front and its propagation should be greatly reduced. Since the 3/16 orifice was known to be oversize, this offered a possible solution to the problem.

The 3/16 diameter valve orifice was reduced to a .055 diameter orifice. This reduction in size and the pressure drop therethrough vastly improved the performance and the original specification of 5-second repressurization from a 2100 psi source was approximated. Fig. 8b shows a test conducted after this change. (This test was run with the bell jar at sea level before opening of the gas cock.) On the basis of the 7 seconds recorded here and on other test results, the orifice was later increased to .062 diameter where the specification of 5 seconds recompression time with 2100 psi supply was complied with.

For cold testing, the unit was charged with air to 1800 psi, which was the highest pressure available at the time of the test. The unit was slowly cooled to -65°F., and after being held at that temperature for several hours it was then "fired" with the chamber at 75,000 ft. The air supply, due to temperature drop, had been reduced to 1660 psi and resulted in a repressurization time of 7 seconds. The chart is shown as Fig. 8c. This was compatible with the low supply pressure, since the rate of discharge would vary directly with the variance in pressure, and at 2100 psi the repressurization time would have been 1660/2100 x 7, or 5.5 seconds.

At the conclusion of this cold test, the regulator had developed leakage. The "O" rings were changed to silicone rubber "O" rings and the regulator retested. All leakage was eliminated. It was also noted that the regulation altitude during the cold test had dropped from 10,000 ft. previously, to about 8,000 ft. when cold. It was found after the test that the aneroid was so close to being "bottomed" at room temperature that differential expansion at low temperatures was causing it to be erratic. Reworking of the aneroid reduced the "bottomed" length by .055 inches. After repeating the cold test on the regulator alone, as above, the regulator now performed normally, regulating at low temperature very close to the room temperature setting, at between 9,700 ft. for low flow and 10,200 ft. for 25 liters per minute.

During the course of the test program on the first prototype unit, the cause of all failures was definitely determined and corrected. Therefore, when the unit was delivered there was every reason to believe that it was a reliable unit without any known potential problems.

2. Second and Third Prototype Tests, Serial Nos. 002 and 003

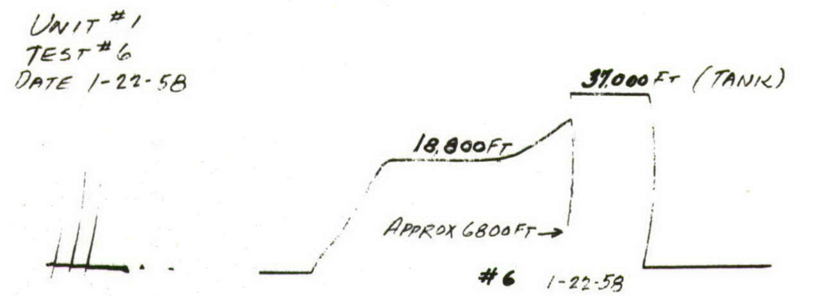
The second and third prototypes were identical to the first prototype except that:

(a) a hexagonal wrench-pad was added to the No. 11702 valve block assembly to facilitate the installation and tightening of the unit into a cylinder.

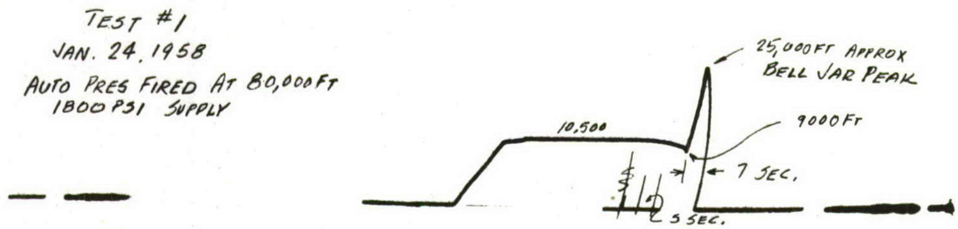
(b) the repressurization time was reduced to 5 seconds at 1800 psi rather than at 2100 psi.

The changes had been requested by WADC. Item (b) was accomplished by enlarging the repressurizing valve orifice from 0.062 to 0.070 diameter.

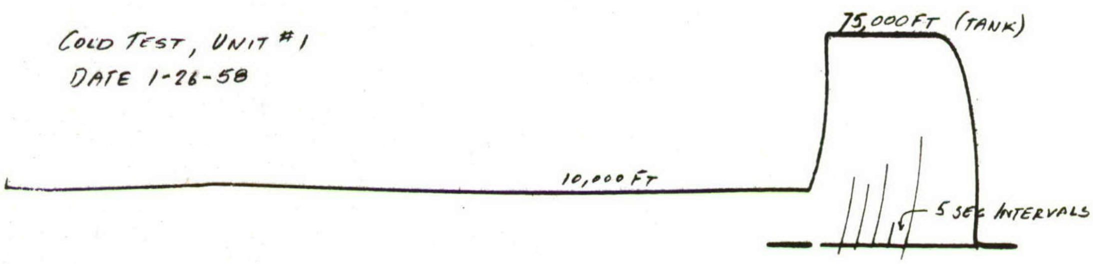
These units were successful in all tests, no failures being recorded in the sequencing of the valves. However, regulation was rougher than in the first prototype (although within tolerance) and the regulators tended to leak in spite of the usual preventatives such as burnishing valves and smoothing the seats. It was finally decided to substitute slightly heavier valve stems and valve closing springs. This was accomplished and the higher spring helped smooth the roughness of regulation



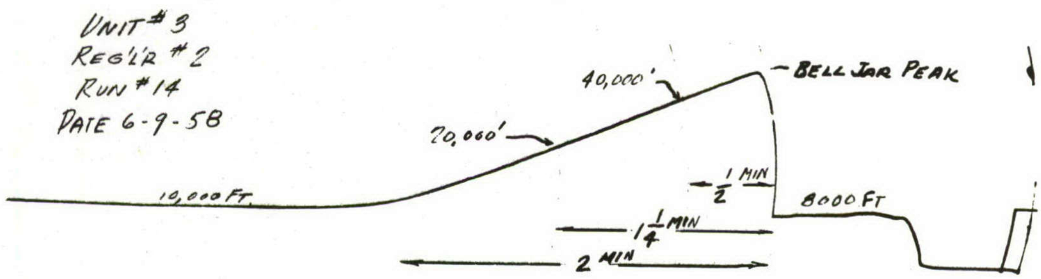

a. Fired with arming cable. Illustrates shock effect with unthrottled 3/16 dia. valve orifice. (air supply purposely insufficient to restore pressure) Recorder in bell jar.




b. Fired with gas cock. .055 dia. valve orifice. Shock effect eliminated. Recorder in bell jar. Bell jar at sea level before run.




c. Cold test repressurization cycle. Recorder connected to main tank, therefore does not show initial bell jar pressure.




d. Repressurization thru regulator alone. Recorder connected to bell jar. Bell jar preevacuated to 8000 ft.

Figure 8. TEST RECORDINGS

as well as to prevent leakage through the valve. The first stage pressure was also reduced slightly to provide smoother regulation; this change being permissible because of the large excess capacity of the regulator.

These second and third units consistently accomplished repressurization in from 4.5 to 4.8 seconds at room temperature and with 1800 psi supply. The test with the highest supply pressure, 2300 psi, was timed at 3.3 seconds.

Tests were also conducted to determine the repressurization time through the regulator alone, assuming the 25 liters per minute leakage concurrently. An example of this run is shown in Fig. 8d. The tank was evacuated to 75,000 ft., the regulator manually tripped at room pressure in order to backseat the valve, with a supply pressure of 1800 psi provided. The bell jar was first taken up to 8000 ft., then the gas cock abruptly opened with the vacuum pump drawing 23 liters per minute from the tank. Repressurization to 11,000 ft. required 2 minutes; however, 40,000 ft. was reached in 1/2 minute, and 20,000 ft. was arrived at after 1-1/4 minutes. Calculations indicated that the regulator was delivering a maximum of about 190 liters of air per minute.

The purpose of the above test was to determine the maximum flow of the regulator and to determine the possibilities of a second repressurization cycle through the regulator alone in case the first ejection attempt was aborted.

Final room temperature and low temperature tests on the second and third prototypes were conducted using the test setup shown in Figs. 9, 10, 11 and 12. A bell jar base with an extension nipple protruding through it was inserted between the repressurization control unit and the repressurization air cylinder (see Fig. 11), and the unit positioned and supported in the cold test chamber (Fig. 9). A metal bell jar was clamped to the base plate for all altitude tests (Fig. 12). The charging fitting on the unit was connected to a source of high pressure air for recharging the unit. The outlet of the bell jar was connected by 2-inch O.D. pipe to a tank simulating the volume of a capsule (Fig. 9). To reduce the length of this pipe to a minimum, and to eliminate the need for elbows or other fittings, the tank was placed adjacent to the cold chamber door (see Figs. 9 and 10) and the pipe connected directly through the slightly opened door. (The resulting opening was packed with rock wool during cold testing.) A sensitive pressure pickup (transducer) was connected to the capsule-volume-tank, and another to the bell jar base. Both pickups were connected to a 3-channel oscillograph (Fig. 8). A mercurial manometer was connected in parallel with each pickup for calibration of the oscillograph. A vacuum line was connected to the bell jar plate, and through a flowmeter to the capsule volume tank. The chamber temperature was automatically controlled and recorded on a Foxboro regulator-recorder.

The results of the tests are shown in Figs. 13 through 18. Figs. 13, 14 and 15 show the tests before cold test, during cold test, and after cold test on unit No. 002. Figs. 16, 17 and 18 show corresponding tests on unit No. 003.

Recompression time from 75,000 ft. to 10,000 ft., with the unit charged to 1800 psi, was well under 5 seconds in all cases except the "before cold test" (Fig. 13) on unit No. 002, in which the time was approximately 5.1 seconds. Adjustment of the control linkage reduced the time satisfactorily.

The capsule-tank and bell jar were satisfactorily maintained well within the specified altitude limits (10,000 $\pm$ 2,000 ft.) for more than 10 minutes after each repressurization.

No difficulties were encountered in recocking the control mechanism, nor in recharging the units.

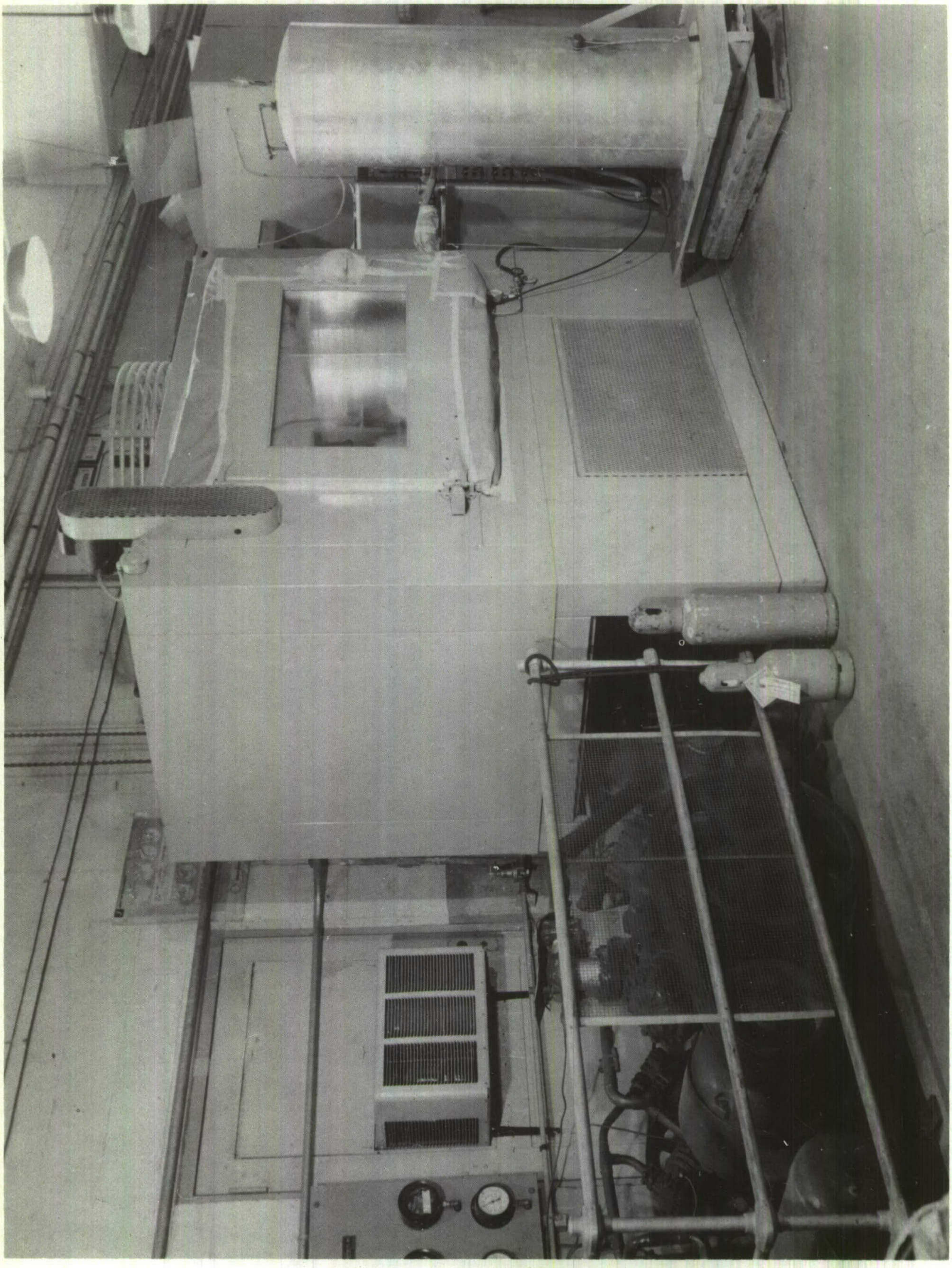


Figure 9. Photograph, COLD TEST CHAMBER & CAPSULE VOLUME TANK

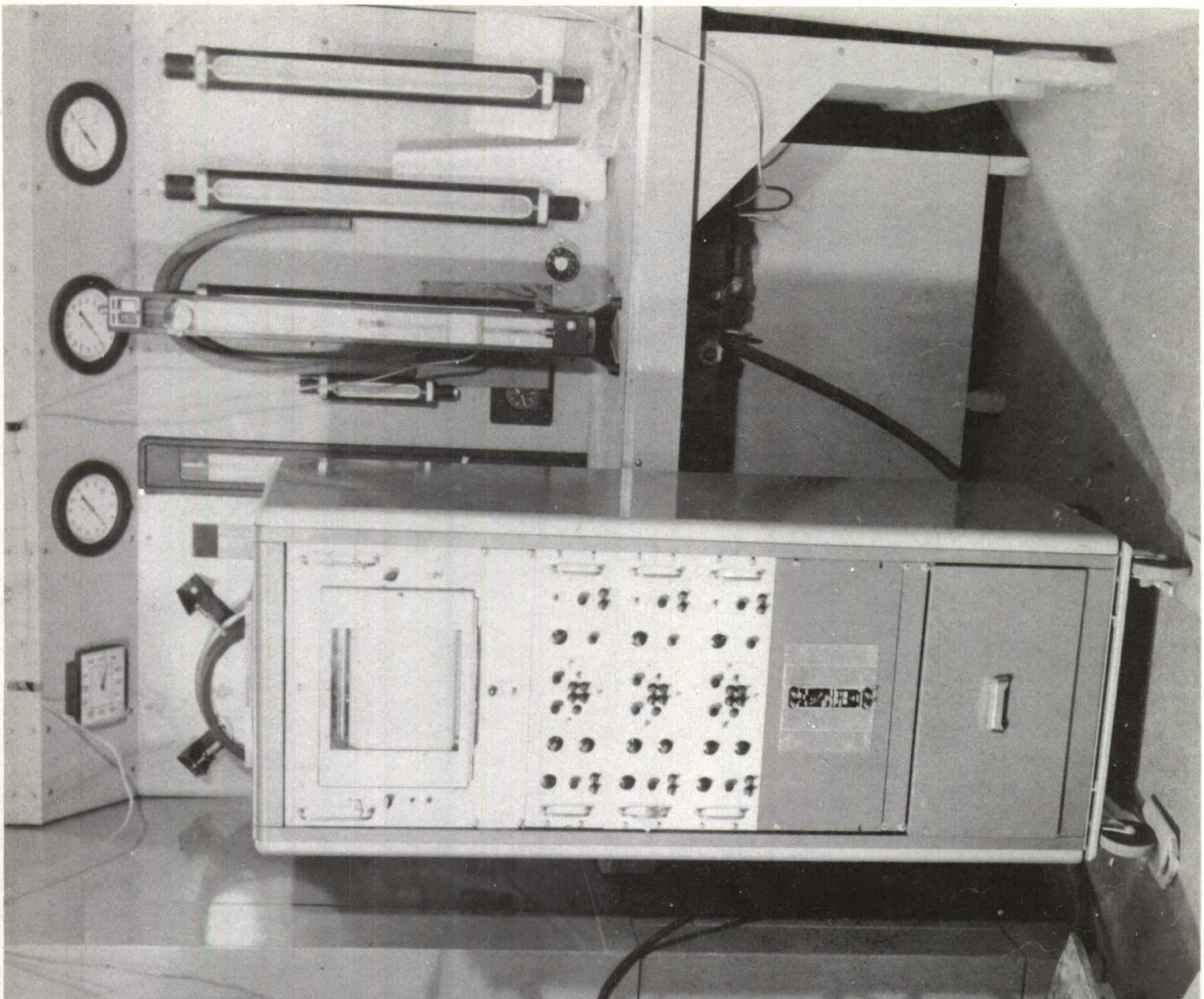


Figure 10. Photograph, CAPSULE VOLUME TANK & INSTRUMENTATION

Figure 11. Photograph, UNIT IN COLD CHAMBER

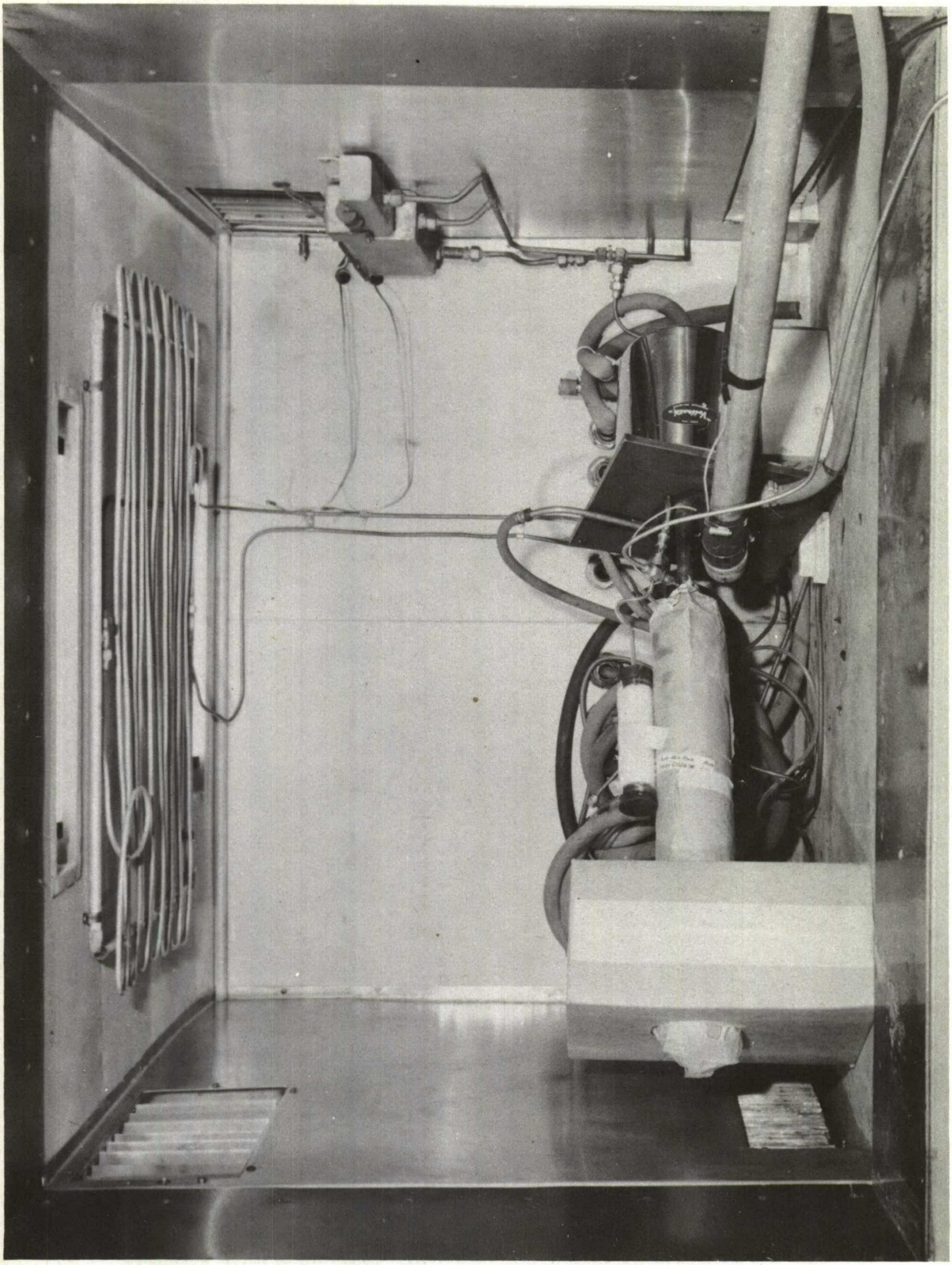
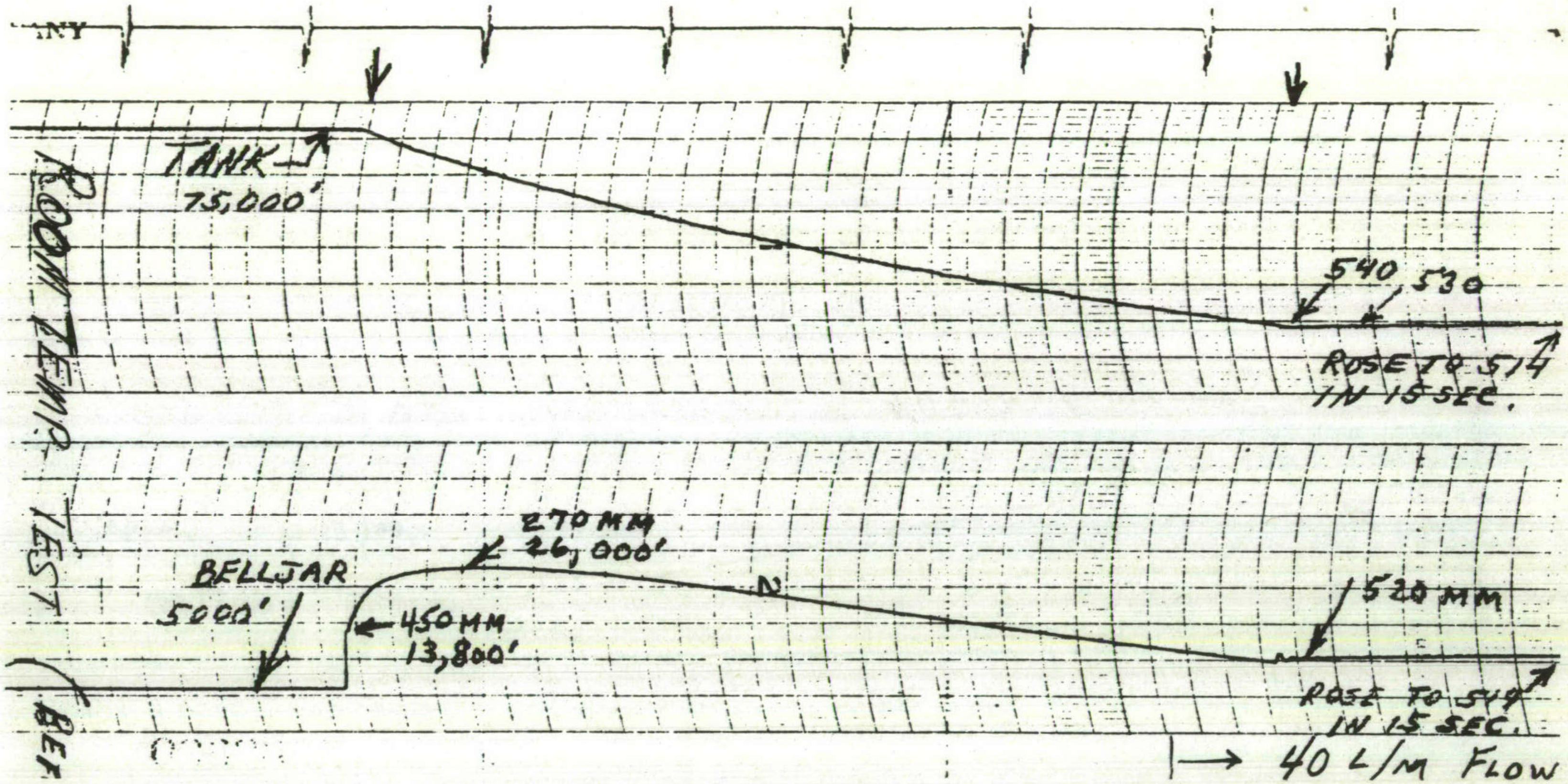


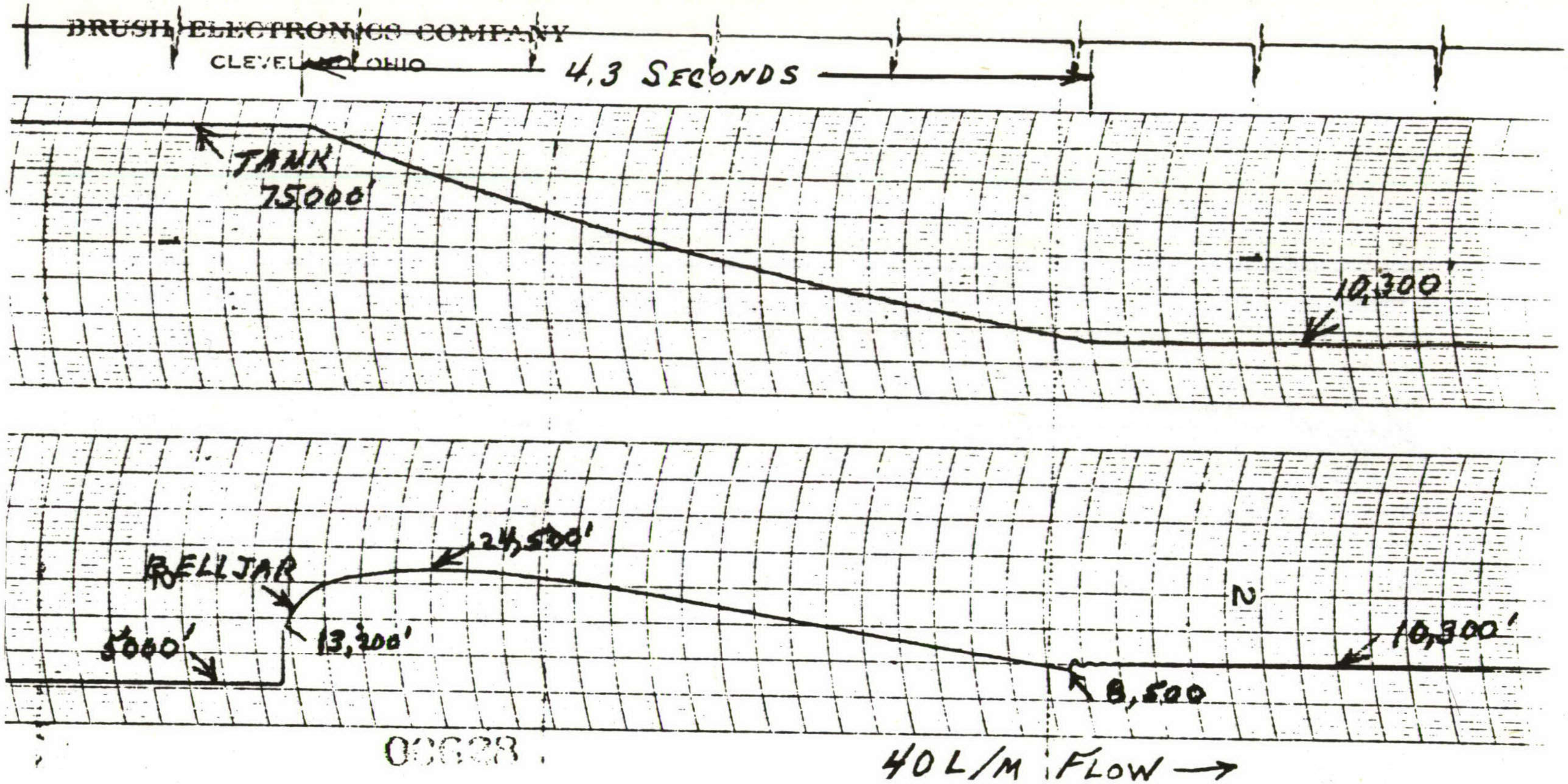
Figure 12. Photograph, UNIT IN COLD CHAMBER, BELL JAR IN PLACE




UNIT NO. 002 BEFORE COLD TEST
INITIAL AIR PRESSURE 1800 PSI

TANK & BELL JAR MAINTAINED AT 514-516 mm FOR 11 MINUTES

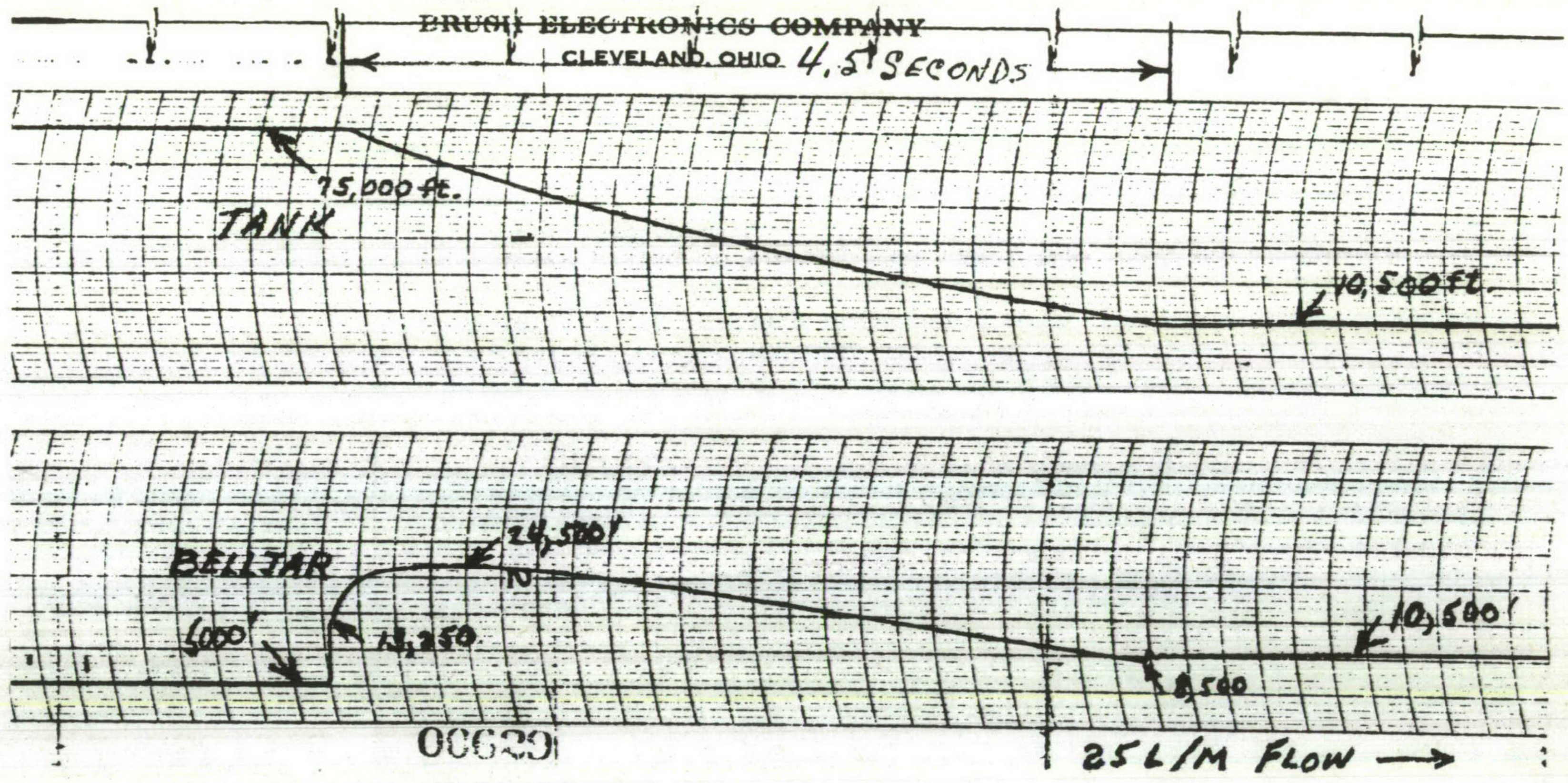
Figure 13. Recording, FINAL TEST, UNIT NO. 002




UNIT NO. 002 COLD TEST -65°F
INITIAL AIR PRESSURE 1800 PSI

TANK & BELL JAR SLOWLY CLIMBED FROM 10,300' TO 11,000'
IN TEN MINUTES

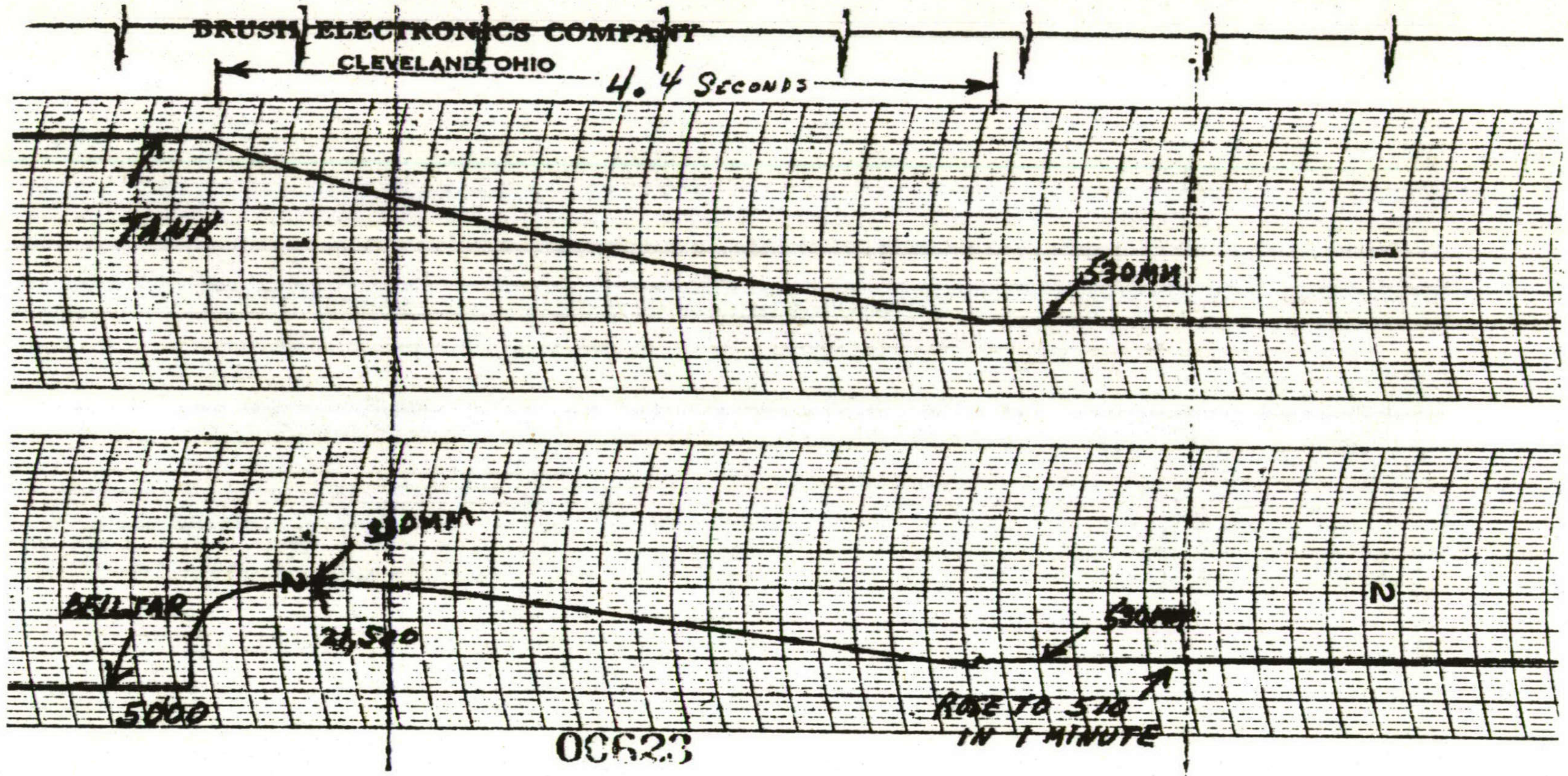
Figureel4. Recording, FINAL TEST, UNIT NO. 002




UNIT NO. 002 AFTER COLD TEST
INITIAL AIR PRESSURE 1800 PSI

BELL JAR & TANK MAINTAINED AT 512-515 mm FOR 12 MINUTES

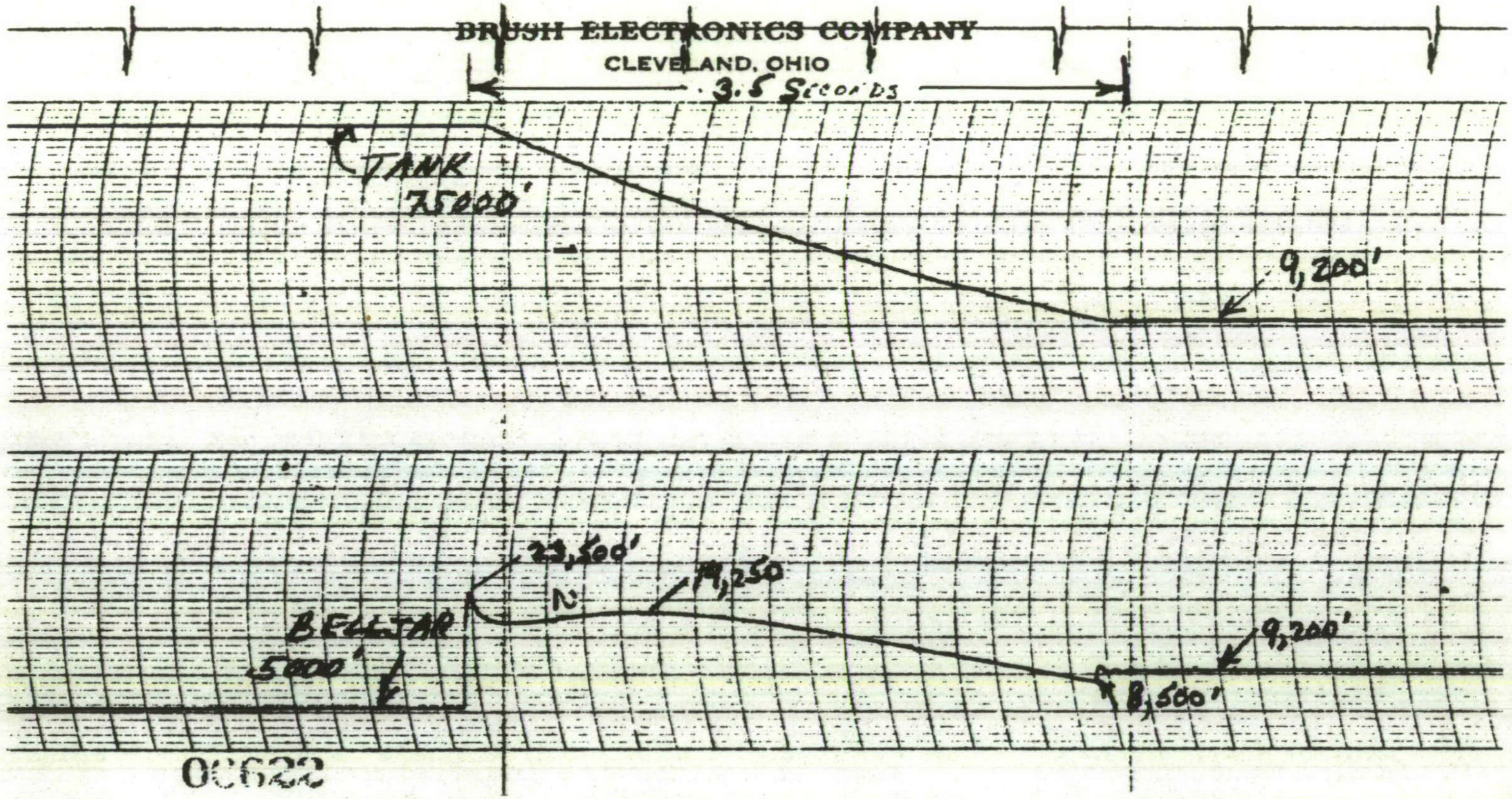
Figure 15. Recording, FINAL TEST, UNIT NO. 002




UNIT NO. 003  AFTER COLD TEST
INITIAL AIR PRESSURE  1800 PSI

AFTER RISING TO 510 mm, BELL JAR & TANK REMAINED AT 510 FOR REMAINDER OF TEST

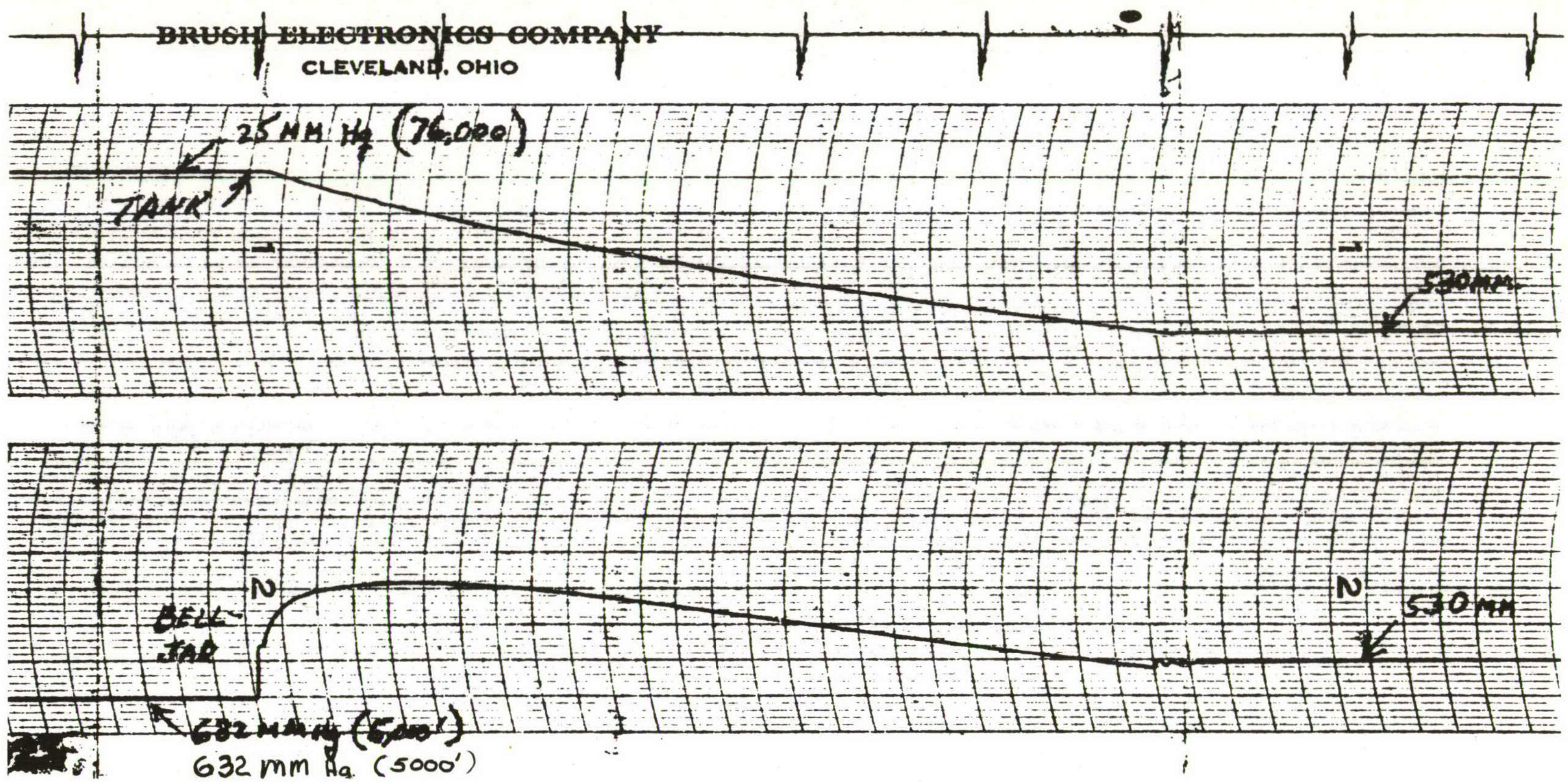
Figure 16. Recording, FINAL TEST, UNIT NO. 003




UNIT NO. 003 COLD TEST -65°F
INITIAL AIR PRESSURE 1800 PSI

BELL JAR & TANK MAINTAINED AT 540 mm FOR 12 MINUTES

Figure 17. Recording, FINAL TEST, UNIT NO. 003




UNIT NO. 003 BEFORE COLD TEST
INITIAL AIR PRESSURE 1800 PSI

BELL JAR & TANK MAINTAINED AT 530 mm FOR 11 MINUTES

Figure 18. Recording, FINAL TEST, UNIT NO. 003

## SECTION IV

## TECHNICAL RECOMMENDATIONS

It is suggested that in compiling requirements for future capsule repressurization units the tolerance allowed on performance figures should be kept as broad as possible; the main emphasis might better be placed on simplicity and high output performance in order to better attain the essentials of complete reliability and minimum size and weight. It is questionable whether the altitude after pressurization should not be increased in order to reduce the mass of air needed for repressurization, thereby reducing the cylinder size and weight. Reducing capsule leakage would also effect a reduction in air requirements.

It is felt that the acceleration requirements should be much higher than those used in the design of the aircraft. However, it is believed that it would be a mistake to attempt to balance aneroids : to do so would sacrifice simplicity and reliability. Minor pressure variations are preferable to increased complexity. It is suggested that all aneroids be mounted with their axes parallel to a single plane, and mounting of the unit in the capsule be specified so that the major capsule accelerations will be normal to this plane, in order to minimize deleterious acceleration effects.

It is believed that the use of air should be specified rather than oxygen. The abrupt valving required by a unit such as this could create a considerable internal explosion hazard if oxygen were to be used. The possibilities of fire or of explosive contaminants in the cockpit are great, and the use of oxygen is certainly hazardous under these conditions.

When specifying the performance of a unit of this nature under cold tests where the flows are somewhat dependent on the source pressure, it would be well to also specify whether the unit is to be charged at normal temperatures, or at the cold test temperature, since a considerable pressure and flow variation may result if the charging temperature is not clearly defined.

Within the year and a half since the subject Exhibit was written, a great deal of thought has been put into this repressurization problem by a number of groups interested in the escape problem. The consensus now leans toward the requirement for the equipment to possess the ability to go through more than one cycle, or to specify total duration of pressurization time consumed by an indefinite number of pre-ejection cycles. In view of the possibilities of pressurization loss due to engine flameouts and various possible battle damage on long missions far from home, it seems prudent to avoid forcing ejection of the crew on the first such failure. Perhaps if given another chance, the damage can be corrected or bypassed, the engines restarted, and the mission completed. That repetition of repressurization cycles should be possible in a system of this type seems to be incontrovertible.

APPENDIX I

SCOTT AVIATION CORPORATION
LANCASTER, NEW YORK

ENGINEERING REPORT
NO. 585
REPORT ON DESIGN STUDY OF
EMERGENCY PRESSURIZATION SYSTEM FOR CAPSULE

Contract AF 33(616)-5005
Item IV
Task No. 63614

DATED 14 June 1957

Compiled by R. J. Elling
R. J. Elling, Project Engr.

Approved by W. O. Packer
W. O. Packer, Engrg. Manager

A. E. Miller
A. E. Miller, Dir. of Research

PHASE I

STUDY PROGRAM AND PRELIMINARY DESIGN

EMERGENCY PRESSURIZATION SYSTEM FOR CAPSULE

## INTRODUCTION

This report represents the conclusion of the first phase of development of an Energency Pressurization System for use in escape capsule to comply with WADC Exhibit WCRDE-181. This Phase I involves the analysis of the problem, the selection of the best system to solve it, and the preliminary design and analysis of such system. It represents culmination of the scope of Paragraph 1.1 of the Exhibit and Scott's recommended Phase I procedure as suggested on Page 29 of Scott Engineering Report No. 552 (Proposal).

In addition to complying with the requirements of the Exhibit, we have set up additional criteria of our own as a result of consultation with designers of the present escape capsules and the resulting familiarization with their needs and problems. We have also added the requirement of manual override as requested by WADC and which is obviously needed to complete the system for universal use.

The preliminary designs are submitted herewith for WADC approval. All development will stop pending receipt of approval of this Phase before Phase II detail design is begun.

## ANALYSIS OF THE PROBLEM

The task has been described by WADC in Exhibit WCRDE-181. The crux of the requirement is contained in Paragraph 3.0 which we quote; "For the purposes of this Exhibit, the capsule volume shall be assumed to be 12.0 cubic feet. The system shall maintain the capsule at an emergency altitude of 12,000 ft. plus or minus 500 ft. Cabin altitude after loss shall be assumed to be 75,000 ft. The emergency altitude shall be attained within a period of five seconds after the ejection sequence has been initiated. The system shall maintain this emergency altitude for a minimum period of 10.0 minutes with an assumed capsule leakage of 25.0 liters per minute".

This Exhibit apparently assumes that as a matter of course pressurization will be lost as the ejection sequence is begun, since it states that "The emergency altitude shall be attained within a period of five seconds <u>after the ejection sequence has been initiated</u>." (our emphasis). It has been our finding that all of the designers of the current capsules are meticulously avoiding a deliberate loss of their existing cabin pressure at the time of ejection. It is apparent that deliberate loss of this pressure would not only be wasteful (since it must be reattained) but would also add an unnecessary physiological strain to an operation which is otherwise physically difficult enough to severely test the endurance of the crew man.

It is known for instance that on the USAF Escape Capsule, being developed by Stanley Aviation, the plan is to close the lower capsule hatch before separation of the capsule so as to trap the existing cabin pressure in the capsule. The capsule is then intended to be completely sealed as it leaves the aircraft.

However, even though deliberate jettison of capsule pressure is avoided, there is a great possibility of accidental loss of pressure, either before, during, or after separation. This could happen at the following:

TIME, CAUSE AND EFFECT OF LOSS OF CAPSULE PRESSURE

| Time | Cause | Recourse |
|---|---|---|
| 1. Before Ejection | Punctured cockpit or loss cabin pressure system | If engine running, may elect to return aircraft home; otherwise may eject over favorable terrain after considerable time |
| 2. Pre-ejection | Faulty capsule operation or bottle damage | Should continue with ejection and depend on emergency system |
| 3. During separation | Aerodynamic and/or deceleration stresses or capsule failure | Emergency pressurization |
| 4. Drag chute recovery | Chute opening shock | Emergency pressurization |
| 5. Main chute descent | Chute opening shock | Emergency pressurization |

Studying this table we find that No. 1 may occur at any time during operation of the aircraft. No. 2 and No. 5 may be separated by as much as one minute in time (assuming main chute does not open above 15,000 ft.) It is, therefore, possible that the main bulk loss of pressure may not occur until sometime after ejection and that, therefore, the quick five-second recovery bulk of emergency air should be saved until this time.

We have no desire to ask for an unnecessary deviation of the specification. We can meet the requirements of the Exhibit by designing a system which will restore cabin pressure in five seconds at any time its loss occurs subsequent to the beginning of the ejection sequence. The above comments are included as information for consideration and discussion.

It should also be noted that Paragraph 2.3.3 of the Exhibit WCRDE-181 calls for satisfactory operation of the unit at maximum aircraft operational accelerations. It is very possible that during separation from the aircraft, the capsule may experience accelerations in excess of 20 gravities and the emergency pressurization will be armed and functioning during this period. We intend to design a unit to operate under greater accelerations than those required in the Exhibit.

In view of the fact that this system is an emergency unit, not primary or necessary for the normal operation of the aircraft, we feel that it should be of absolute minimum weight and size and that the performance specifications which it must meet should be designed primarily to provide reliability, not accuracy. We believe, therefore, that in the interests of weight and cost the requirement of Paragraph 3.0 of the Exhibit should be revised to require emergency altitude of 12,000 ft. plus or minus 2,000 ft. rather than plus or minus 500 ft. on the basis that such accuracy serves no useful purpose and requires more elaborate, expensive, and possibly heavier and more bulky designs. We request that this deviation be granted before Phase II is begun.

At the time of our proposal, Report No. 552, proposed four different variations of this device. In light of the beforementioned discussion, we can now eliminate some of these systems from consideration.

System No. 1 used a breakaway fitting which automatically dumped one of a pair of bottles at the time of separation. If the major loss of pressure did not occur until some time after separation, the first bottle would be wasted through the cockpit relief valves and would not be available when the major pressure loss did occur. The regulator used to restore leakage would be entirely inadequate to counter this later major pressure loss.

System No. 2 still has the disadvantage of the two bottle requirement in that a fixed proportion of air is committed initially whether needed or not, reducing that available to replenish leakage later on. In addition, the extra plumbing required by the use of two bottles instead of one is both heavy and uneconomical with respect to space.

System No. 3 has less parts by virtue of the use of a single bottle. It may be wasteful, however, because it still commits a definite proportion of its air to the initial charging of the cabin. This may not be required and could be used later, especially if the proper controls are provided so that this system may be used for normal operational emergencies without ejecting from the aircraft.

System No. 4 appears to be the best for the following reasons. It only requires one bottle. It saves its excess initial charging air for use as leakage replenishment. It eliminates the need for a relief valve, and if properly controlled by a manual pull it will act as an efficient emergency cabin pressurization system when ejection is not contemplated.

The following sections of the report will describe how we have implemented this system.

## PROPOSED SYSTEM FOR PHASE II DEVELOPMENT

The system resulting from our design studies is shown in General Arrangement Drawing No. 11700. We have integrated the system so that it mounts directly on the supply bottle resulting in a minimum size and weight installation. Obviously, where installation dictates, the systems components could be separated in space and joined by a plumbing system; however, for purposes of this development, the package system seems much more desirable.

Adhering to the Exhibit, 12 cubic feet is needed for initial repressurization and 250 liters for leakage compensation, all measured at the 12,000 ft.

level. This gives a total of 20.83 cu.ft. at 12,000 ft. or at 9.344 PSI, and requires a bottle size of 186 cu.in. at 1800 PSI or 159 cu.in. at 2100 PSI. The nearest bottles on the large side are the 205 cu.in. AN6025A205 and 205A which provide a surplus of from 10 to 29 percent, depending on whether an 1800 PSI or 2100 PSI system is chosen. This surplus imposes a weight penalty of almost like amount on our particular system. This bottle size does give a choice of shapes, however, which may be advantageous to the installation engineer.

A valve block (11702) is mounted on the bottle by means of a 1/2 inch pipe thread (if bottle 205 is used, a reducer bushing must be supplied). This block mounts the two main components of the system, the valve emergency (11701) and the regulator (11703); as well as a filler valve (MS 28889), a gage Type L-2 (with dial converted for air use), and a Scott "safety outlet assembly" (10707-2). The valve emergency is supplied with a lanyard or Bonderite cable arming control. This cable will be attached to some element of the separation mechanism for automatic arming during capsule ejection and to a "Green Apple" for manual arming of the device. All elements are mounted on three sides of the block, permitting a "blank" side for use against the skin of the aircraft.

## SEQUENCE OF OPERATION

The system is armed either by the separation or pre-separation actuation of the capsule, or manually by the "Green Apple". When the cabin pressure first falls to 12,000 ft. the first aneroid actuator fires, opening the emergency valve but not permitting it to back seat. This permits a free flow of air around the valve stem and into the capsule by-passing the regulator; the diffuser orifices will be restricted to delay the operation to the five-second period allowed. This first release of the toggle mechanism also arms the second aneroid actuator so that as the cabin pressure again builds up to the 12,000 ft. level the second aneroid actuator operates. This second operation permits the main valve to back seat so that all of the air must now flow through the 11703 regulator to pressurize the cockpit. This regulator is controlled by absolute cabin pressure and will permit the passage of at least 25 liters per minute to compensate for leakage.

This system is a "demand" system in that it supplies only that amount of air needed to repressurize and saves the remaining air for compensation against leakage. It is, however, a "one shot" system (as are all the other proposals) in that it sequences through only one major recompression cycle. It is for this reason that we use an arming control and a first stage aneroid rather than releasing the major recompression air directly by means of the "arming" cable. This air may not be needed at separation but may be badly needed a few seconds later when the fins or a drag "chute" are deployed. The aneroid senses this need and conserves the air until it is required.

This entire system uncharged will weigh 12.06 lbs., of which 9.31 lbs. is bottle weight and only 2.75 lbs. is attributable to the Scott-developed portion of the system.

## THE ELEMENTS OF THE SYSTEM

### Valve - Emergency Pressurization (11701)

Referring to the drawing, we see that the valve itself is of a poppet type with a nylon disk seated on an annular lipped metal orifice of 1/4 inch diameter which is considered ample for the required flow. The valve is held

normally closed by a dead center toggle (see "Operating Schematic"). The seat pressure may be adjusted by a nut at the valve stem. The toggle is held closed by a system of sears. A heavy spring is used to bias the system toward the opened position. The entire linkage is mounted in an aluminum alloy cast frame and covered by a sheet aluminum alloy housing.

Two aneroid units are used to operate and properly sequence this toggle linkage. These aneroids are of a unique, very decisive type and are necessary on this device because, in the case of the first, a high sear load must be overcome, and the second, because of the extreme rate of airflow during the major repressurization must actuate sharply in order to conserve the remaining air supply. The secret of these aneroid assemblies is the inclusion of an end loaded, highly responsive reed element which acts in series with the aneroid. This element stores the cocking energy put into it. It is cocked against a stop which is very near dead center. The aneroid may bear against this reed continually but only when it attains the required load can it unseat this reed. At this time the reed snaps through, releasing its own stored energy and that built up in the aneroid by the pressure differential also. This system then is force-sensitive rather than position-sensitive, and since we are dealing with pressures (or force) it is very accurately controlled. It largely eliminates the effects of friction and makes partial operation impossible. The reed, therefore, both controls and amplifies the effect of the aneroid. Since it cannot move at all until operation, it eliminates errors due to resonant vibrations.

Two such aneroid actuators are used; the first actuator operating on reducing pressure may be called a compression type, the second operating on increasing pressure might be called a tension type.

The first aneroid bears against a two-piece sear crank. This system is normally safetied by the arming crank which holds half the sear crank firmly against the aneroid head but still permits the other half of the sear to latch in while recocking the unit. The second aneroid actuator is safetied by an interlocking safety lever which does not permit operation of the second aneroid until the toggle has been displaced. Two-piece cranks are required here to permit cocking the aneroids.

The operation of the unit is illustrated in the "Operating Schematic" views. Position one shows the unit in its normal closed position. The arming pin may now be pulled either automatically or manually making the unit ready for action. When the pressure drops to the equivalent of 12,000 ft., the first actuator triggers. This releases the first sear and the toggle, driven by a "nudger" on the sear lever and the main spring, flies to position two where it is stopped by an Ensolite cushion on the secondary lever. This opens but does not back seat the valve, and arms the second unit by removing the restriction on its crank. The air can now freely pass by the valve and diffuse into the capsule. The valve is prevented from back seating by the secondary lever which is held by the second sear. The Ensolite cushion absorbs much of the dynamic stopping energy.

As the cabin pressure builds up the second actuator now fires, releasing the second sear and permitting the valve to travel further until it back seats. This back seat now prevents the air from escaping uncontrolled, forcing it through the regulator.

The unit is reset by removing the cover, recocking the first aneroid actuator, setting arming control to "safe" and then, by means of a 3/8 wrench inserted over the end of the toggle crank, drawing the toggle back to the dead center position. All remaining elements will cock and latch in automatically.

The unit has 6 mounting studs at its base so that it may be turned in any direction in 60° intervals.

Regulator - Absolute Pressure (11703)

In the interests of achieving a minimum weight and size we have applied considerable thought to the design of the regulator. The result, we believe, is a thoroughly serviceable, extremely small two-stage unit.

The first-stage consists simply of a spool with two "O" rings, a simple nonadjustable spring balancing the differential areas of the spool ends. We are able to use "O" rings because we are not concerned with great accuracy and because we only need a short-lived regulator. The rest of the system is such that the rings are under pressure only while the unit is being activated. We believe this unit will be satisfactory to regulate first-stage air to 100 PSI plus or minus 25 PSI which is all the accuracy that is desired.

In the second stage we have used an aneroid of low spring rate and 1.2 square inches effective area which is ample to overcome the friction and the variation in seat loading due to the fluctuation of first-stage pressure. The unit although housed compactly is fairly conventional, though the altitude adjustment is made by turning and subsequently locking the outside case.

The aneroid is designed to collapse at 10,000 ft. altitude which permits the use of a light internal spring and results in a low spring rate and consequently small position-pressure error. The second-stage valve is fully guided.

There is expected to be a slight error due to the flow impinging on the aneroid. This is accepted as a penalty inherent in the extremely small size.

This unit is actually designed in anticipation of relief in the altitude maintenance tolerance as requested under the "Analysis of the Problem". However, it is theoretically capable of meeting the requirement of the Exhibit with perhaps only minor refinements, one of which may be a slightly larger aneroid.

OTHER ELEMENTS

All other elements are either well-known or self-explanatory. The filler unit is an MS 28889 standard unit. The gage is a standard Type L-2, MIL-G-7601A, except that the word "Oxygen" must be removed from the face.

The pressure relief valve is a standard Scott assembly consisting of silver alloy "shear out" disk with a container to catch it after rupture in order to avoid jamming the overboard lines.

The bottle is a standard AN 6025A205 or 205A. It is slightly oversize for the job. The 205 bottle has a 1 inch pipe thread so requires a reducer bushing to fit our 1/2 inch thread which has been supplied to fit the 205A bottle.

## CONCLUSION

We believe that this preliminary design meets and exceeds the requirements of Exhibit WCRDE-181, that the altitude maintenance tolerance should be broadened as herein requested, and that this report and the Drawings 11700, 11701, 11702 and 11703 submitted herewith, complete all contractual obligations of the Phase I program. We will await your comments and approval before proceeding to Phase II.

AD-216307
Scott Aviation Corp, Lancaster, New York.
DEVELOPMENT OF AN EMERGENCY PRESSURIZATION SYSTEM FOR AN ESCAPE CAPSULE, by A. E. Miller and E. H. Replogle. May 1959, 49p. incl. illus. tables. (Proj. 6352; Task 63105) (WADC TR 58-397)
(Contract No. AF 33(616)-5005)
Unclassified Report

An Emergency Pressurization System for an Escape Capsule was developed. It included its own "bottled" high pressure air supply and a sequential system of controls whereby, after being armed either manually or by separation from the aircraft, the system automatically (as a result of the sensing of the drop of cockpit pressure) releases its air at the rate required for fast repressurization. It then cuts short the fast re-

( over )

UNCLASSIFIED

I. Miller, A. E.
Replogle, E. H.
II. Wright Air Development Center, Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio
III. Contract AF 33(616)-5005

UNCLASSIFIED

AD- 216307

pressurization as soon as the capsule pressure has again returned to a safe level, and directs the air through an absolute pressure regulator which maintains this level, compensating for capsule leakage.

It was found that the second aneroid triggering device could be set off prematurely by shock waves formed by the too sudden release of unrestricted pressure when attempts were made to pressurize in time considerably shorter than 5 seconds. The pressure waves were recorded and means devised to avoid them.

The reasons for choice of the types of mechanical elements provided and the effects of acceleration and environment on their satisfactory operation are discussed. A brief review of the test results is included, and the report is concluded with recommendations to writers of future specifications for equipment of this nature.

UNCLASSIFIED

UNCLASSIFIED

AD-216307
Scott Aviation Corp, Lancaster, New York.
DEVELOPMENT OF AN EMERGENCY PRESSURIZATION SYSTEM FOR AN ESCAPE CAPSULE, by A. E. Miller and E. H. Replogle. May 1959, 49p. incl. illus. tables. (Proj. 6352; Task 63105) (WADC TR 58-397)
(Contract No. AF 33(616)-5005)
Unclassified Report

An Emergency Pressurization System for an Escape Capsule was developed. It included its own "bottled" high pressure air supply and a sequential system of controls whereby, after being armed either manually or by separation from the aircraft, the system automatically (as a result of the sensing of the drop of cockpit pressure) releases its air at the rate required for fast repressurization. It then cuts short the fast re-

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pressurization as soon as the capsule pressure has again returned to a safe level, and directs the air through an absolute pressure regulator which maintains this level, compensating for capsule leakage.

It was found that the second aneroid triggering device could be set off prematurely by shock waves formed by the too sudden release of unrestricted pressure when attempts were made to pressurize in time considerably shorter than 5 seconds. The pressure waves were recorded and means devised to avoid them.

The reasons for choice of the types of mechanical elements provided and the effects of acceleration and environment on their satisfactory operation are discussed. A brief review of the test results is included, and the report is concluded with recommendations to writers of future specifications for equipment of this nature.

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